Explaining Export Varieties: the Role of Comparative Advantage

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Abstract

This paper examines how factor proportions determine product varieties, or the extensive margin, in exports of countries. A model of the economy with two countries, two factors, and a multitude of industries with productivity-heterogeneous firms explains the relative number of export varieties in each country. A quasi-Heckscher-Ohlin prediction on export varieties emerges from the model: Countries export more varieties in industries in which the countries have a comparative advantage. Empirical tests using disaggregated data on the U.S. imports confirm the theoretical prediction by showing that relatively (un)skilled-labor abundant countries tend to export more varieties in more (un)skilled-labor intensive industries. The paper provides both a theoretical foundation and empirical evidence for the importance of factor proportions in explaining the pattern of exports of product varieties.

Keywords: Comparative Advantage, Heckscher-Ohlin, export variety, intra-industry product variation, firm heterogeneity

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1. Introduction

The recent trade literature on export or import variety has grown rapidly. Although the increases in product variety have long been known as an important source of gains from trade, empirical studies on the significance of the growth of product varieties, or "extensive margin," in international trade are relatively new. For example, Kehoe and Ruhl (2003) show that the trade of new goods (extensive margin) explains a larger proportion of the growth of trade following trade liberalization than the increase in the volume of previously-traded goods (intensive margin) does. Hummels and Klenow (2005) demonstrate that more than a half of greater exports of larger countries are explained by a larger variety or extensive margin of their exports. A series of empirical studies by Funke and Ruhwedel (2001a, 2001b, 2005) indicates that the growth of product variety in exports has a significant effect on the economic growth in various countries and regions. Feenstra and Kee (2004b, 2008) also provide evidence supporting the positive impact of export variety on productivity growth for a sample of both developed and developing countries. Broda and Weinstein (2004) empirically show how much the increase in imported variety mattered for the welfare of United States. Their results suggest that the U.S. welfare has increased by 3% due to the increase in the extensive margin of its import.[1]

[1] Another important branch of this recent literature focuses on the quality differentiation of exported goods. Hummels and Klenow (2005) investigate the "quality margin" in exports in addition to the extensive and intensive margins. Hallak (2006a) attemps to identify the effect of product quality on the direction of international trade. The paper empirically investigates whether importers at a higher income level tend to buy more varieties of products from exporters with higher income as well because they tend to produce higher quality products. In a related paper Hallak applies his framework of product quality and uses sectoral level data to provide evidence for the Linder hypothesis according to which international trade is more intensive between countries with similar income levels than those that differ (Hallak, 2006b). Choi, Hummels and Xiang (2006) explore the effect of income distribution on varieties in trade, whose key insight is that consumers with higher income will buy goods with higher quality rather than buy greater quantities of goods that vary in the quality dimension.

Literature has investigated product varieties in international trade, or the extensive margin, as an influential factor on various aspects of the economy such as productivity, growth, and welfare. However, influential factors *on the extensive margin*, or what determine the patterns of varieties in trade, have not been much explored, except for a very few pieces such as Hummels and Kleknow (2005) that has shown the effect of the size of the economy on the extensive margin and Kehoe and Ruhl (2003) demonstrating that the reduction of trade friction is associated with an increase in variety in exports.[2] In addition, although the preceding research has examined the cross-country patterns of product varieties in international trade, few studies have investigated the patterns of traded varieties *across industries*. To fill this gap in literature, in the current paper I examine a determinant of the cross-industry patterns of product varieties in the exports of countries, as well as how the patterns differ across countries. Specifically, I examine whether the traditional theory of comparative advantage based on factor proportions explains the observed cross-industry patterns of varieties in countries' exports.

Moreover, most of the existing studies on the variety or extensive margin of trade have built on the framework of the monopolistic competition model by Krugman (1979), which first brought product variety in international trade into focus. However, empirical research on the topic has not been well connected to heterogeneous firm models that have been recently developed and widespread, while Feenstra and Kee (2008) is an attempt to this new direction.[3] My study contributes to this new literature by considering the modern framework of heterogeneous firms together with the traditional framework of factor proportion theory to

[2] Debaere and Mostashari (2010) have also shown that changes in tariffs impact the extensive margin of countries' exports. However, they have also found that *unspecified* country- and industry-specific factors are more influential on export varieties. The present study suggests what one of those factors actually is.
[3] Theoretical work by Chaney (2008) also investigates the extensive (and intensive) margin in trade under the framework of a heterogeneous firm model.

explore, both theoretically and empirically, the role for the comparative advantage in export variety.

This study first follows other paper of mine (Kamata, 2010), which extends Melitz (2003) and Bernard, Redding, and Schott (2007) to a broader framework, to develop a theoretical model in which countries vary in factor endowment, industries differ in factor intensity, and firms are heterogeneous in productivity within industries. The paper next derives a prediction that relates product varieties in a country's exports to the degree of relative factor intensity of industries. This prediction is empirically tested using data on the U.S. imports from Feenstra, Romalis, and Schott (2002) that finely classify traded goods according to the ten-digit Harmonization System (HS). The study also employs the data on factor use in various industries from the U.S. Census of Manufactures, as well as the data on factor abundance of a number of countries from Hall and Jones (1999). The empirical analysis supports my quasi-Heckscher-Ohlin prediction on product varieties in exports; i.e, countries export more varieties in industries in which they have a comparative advantage in terms of factor proportions.

The current paper also adds to the literature on firm-level heterogeneity by providing empirical evidence for an unexplored aspect of the recent models. In particular, in contrast to the existing studies, this paper performs an empirical test for a heterogeneous firm model without relying on firm-level data for a particular country but using industry-level data that are more publicly accessible and available for a broader range of countries.[4]

The paper proceeds as follows. Section 2 develops the theoretical model in order to provide an implication for the relationship between factor proportions and export variety.

[4] Feenstra and Kee (2008) also utilize country- and industry-level data for the test of a heterogeneous firm model.

Section 3 proposes an empirical approach to test the theoretical prediction, and Section 4 describes the data. The results of the empirical tests are presented in Section 4. Section 5 concludes.

2. The Model

I build this study on the model by myself (Kamata, 2010), which extends the model by Bernard, Redding, and Schott (2007) to the framework of two countries, two factors, and *many* industries. In what follows I present the key elements of the model to derive the prediction on the relationship between product varieties in exports and the comparative advantages of countries.[5]

Basic Framework

The modeled economy comprises two countries, Home (H) and Foreign (F); two factors, skilled labor (S) and unskilled labor (U); and N (>2) industries. Within each industry there is a continuum of firms that are heterogeneous in productivity. Countries differ in factor endowments: Home is relatively abundant in skilled labor, and Foreign is relatively abundant in unskilled labor; i.e., $\frac{\overline{S}^H}{\overline{U}^H} > \frac{\overline{S}^F}{\overline{U}^F}$ where $\overline{S}^H$ ($\overline{U}^H$) and $\overline{S}^F$ ($\overline{U}^F$) denote the total inelastic supply of (un)skilled labor in Home and Foreign, respectively.

Consumption

The preference of the representative consumer is described by the following utility function:

[5] The further description of the model is left to my other paper (Kamata, 2010).

$$U = C_1^{\alpha_1} C_2^{\alpha_2} \ldots C_N^{\alpha_N}, \quad \sum_{i=1}^{N} \alpha_i = 1 \tag{2.1}$$

The consumption index C_i for each industry i =1,……,N takes the following CES (or Dixit-Stiglitz) form:

$$C_i = \left[\int_{\omega \in \Omega_i} q_\omega{}^\rho d\omega \right]^{\frac{1}{\rho}} \tag{2.2}$$

where ω indexes product varieties within an industry, Ω_i denotes a set of available varieties in Industry i, and q_ω represents the quantity of each variety consumed. The ideal price index for Industry i is defined as follows:

$$P_i = \left[\int_{\omega \in \Omega_i} p_{i,\omega}{}^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} \tag{2.3}$$

where $\sigma = \dfrac{1}{1-\rho} > 1$ is the constant elasticity of substitution across varieties.

Production and Export

Each firm produces a unique variety of products. A firm's production technology, which exhibits economies of scale, is described by the following cost function:

$$\begin{aligned} \Gamma_{i,\omega}^H &= \left[f_i + \frac{q_{i,\omega}}{\phi_{i,\omega}} \right] \cdot (s^H)^{\beta_i} (w^H)^{1-\beta_i} \\ \Gamma_{i,\omega}^F &= \left[f_i + \frac{q_{i,\omega}}{\phi_{i,\omega}} \right] \cdot (s^F)^{\beta_i} (w^F)^{1-\beta_i} \end{aligned} \tag{2.4}$$

where s is the wage for skilled labor, w is the wage for unskilled labor, and the superscripts H and F denote Home and Foreign, respectively. The intensities of the two factors in each industry (β_i and 1- β_i) are common across countries, but the firm-specific productivity level

$\phi_{i,\omega}$ varies the marginal cost across firms. The industries are ranked according to the skilled-labor intensity (β_i) such that $0 < \beta_1 < \beta_2 .... < \beta_{N-1} < \beta_N < 1$.[6]

The optimal pricing of each firm equals a constant markup ($1/\rho$) over the marginal cost of production. Therefore, for domestic sales, each firm charges the following price for its product:

$$
\begin{aligned}
p^H_{i,\omega}(\phi_{i,\omega}) &= \frac{(s^H)^{\beta_i}(w^H)^{1-\beta_i}}{\rho\phi_{i,\omega}} \\
p^F_{i,\omega}(\phi_{i,\omega}) &= \frac{(s^F)^{\beta_i}(w^F)^{1-\beta_i}}{\rho\phi_{i,\omega}}
\end{aligned}
\tag{2.5}
$$

Firms can also export their products by incurring the (amortized per-period) fixed costs $f_{xi}(s)^{\beta_i}(w)^{1-\beta_i}$ ($f_{xi} > 0$), as well as the variable "iceberg" shipping costs such that only $1/\tau_i$ ($\tau_i > 1$) of the shipped quantity reaches to the other country. The optimal price of a firm's product for exporting is thus as follows:

$$
\begin{aligned}
p^H_{xi,\omega}(\phi) \equiv \tau_i \cdot p^H_{i,\omega}(\phi) &= \frac{\tau_i (s^H)^{\beta_i}(w^H)^{1-\beta_i}}{\rho\phi_{i,\omega}} \\
p^F_{xi,\omega}(\phi) \equiv \tau_i \cdot p^F_{i,\omega}(\phi) &= \frac{\tau_i (s^F)^{\beta_i}(w^F)^{1-\beta_i}}{\rho\phi_{i,\omega}}
\end{aligned}
\tag{2.6}
$$

Accordingly, a firm's revenue from the domestic sales is:

$$
\begin{aligned}
r^H_{i,\omega}(\phi_{i,\omega}) &= \alpha_i Y^H \left(\frac{(s^H)^{\beta_i}(w^H)^{1-\beta_i}}{\rho\phi_{i,\omega} P^H_i} \right)^{1-\sigma} \\
r^F_{i,\omega}(\phi_{i,\omega}) &= \alpha_i Y^F \left(\frac{(s^F)^{\beta_i}(w^F)^{1-\beta_i}}{\rho\phi_{i,\omega} P^F_i} \right)^{1-\sigma}
\end{aligned}
\tag{2.7}
$$

and the revenue from the overseas sales is:

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[6] To be accurate, β_i indicates the Cobb-Douglas cost share of skilled labor. However, since the equilibrium relative factor intensity in each industry is $\frac{S_i}{S_i + U_i} = \frac{\beta_i}{\beta_i + (1-\beta_i)\cdot(s/w)}$ for any relative wage $s/w > 0$, $S_i/(S_i+U_i)$ is larger for a larger β_i.

$$
\begin{aligned}
r_{xi,\omega}^{H}(\phi) &= \alpha_i Y^F \left(\frac{\tau_i (s^H)^{\beta_i} (w^H)^{1-\beta_i}}{\rho \phi_{i,\omega} P_i^F} \right)^{1-\sigma} \\
r_{xi,\omega}^{F}(\phi) &= \alpha_i Y^H \left(\frac{\tau_i (s^F)^{\beta_i} (w^F)^{1-\beta_i}}{\rho \phi_{i,\omega} P_i^H} \right)^{1-\sigma}
\end{aligned}
\tag{2.8}
$$

where Y^H and Y^F are the total national incomes of Home and Foreign, respectively.

Zero Profit

Firms need to maintain at least zero profit in each of the domestic and export markets. Firms do not export if they are not profitable enough to satisfy the zero-profit condition for the export market. Firms do not even serve the domestic market if they are not profitable enough to fulfill the zero-profit condition for the domestic market. The zero-profit condition for a firm in each market is described such that the firm's revenue net of the variable costs equals the fixed costs: that is, for the domestic market,

$$
\begin{aligned}
\frac{r_{i,\omega}^{H}(\phi_{i,\omega})}{\sigma} &= f_i (s^H)^{\beta_i} (w^H)^{1-\beta_i} \Leftrightarrow r_i^H(\phi_i^{*H}) = \sigma f_i (s^H)^{\beta_i} (w^H)^{1-\beta_i} \\
\frac{r_{i,\omega}^{F}(\phi_{i,\omega})}{\sigma} &= f_i (s^F)^{\beta_i} (w^F)^{1-\beta_i} \Leftrightarrow r_i^F(\phi_i^{*F}) = \sigma f_i (s^F)^{\beta_i} (w^F)^{1-\beta_i}
\end{aligned}
\tag{2.10}
$$

and for the export market,

$$
\begin{aligned}
\frac{r_{xi,\omega}^{H}(\phi_{i,\omega})}{\sigma} &= f_{xi} (s^H)^{\beta_i} (w^H)^{1-\beta_i} \Leftrightarrow r_{xi}^H(\phi_{xi}^{*H}) = \sigma f_{xi} (s^H)^{\beta_i} (w^H)^{1-\beta_i} \\
\frac{r_{xi,\omega}^{F}(\phi_{i,\omega})}{\sigma} &= f_{xi} (s^F)^{\beta_i} (w^F)^{1-\beta_i} \Leftrightarrow r_{xi}^F(\phi_{xi}^{*F}) = \sigma f_{xi} (s^F)^{\beta_i} (w^F)^{1-\beta_i}
\end{aligned}
\tag{2.11}
$$

ϕ_i^* and ϕ_{xi}^* in the above equations denote the productivity "cutoffs" for firms serving the domestic market (or "domestic producers") and exporters, respectively. The first cutoff divides domestic producers from firms exiting from the domestic market, and the second divide exporting firms from domestic producers.[7]

Entry and Equilibrium under Costly Trade

To enter the domestic market, firms must incur a sunk entry cost, which takes the following form:

$$f_{ei}(s)^{\beta_i}(w)^{1-\beta_i}, \quad f_{ei} > 0 \tag{2.12}$$

Firms discover their productivity after the entry. The productivity parameter ϕ is randomly drawn from a distribution $G(\phi)$, which is common across countries. Each firm, or a potential entrant, decides to enter (to realize its own productivity by paying the sunk entry cost) if its pre-entry or *ex ante* expected future profit stream is at least as large as the sunk entry cost. In stationary equilibrium, the *ex ante* expected future profit exactly equals the entry cost, which determines the free-entry condition described as follows:

$$\begin{aligned} V_i^H &= \frac{1-G(\phi_i^{*H})}{\delta}[\pi_i^H(\overline{\phi}_i^H) + \chi_i^H \cdot \pi_{xi}^H(\overline{\phi}_{xi}^H)] = f_{ei}(s^H)^{\beta_i}(w^H)^{1-\beta_i} \\ V_i^F &= \frac{1-G(\phi_i^{*F})}{\delta}[\pi_i^F(\overline{\phi}_i^F) + \chi_i^F \cdot \pi_{xi}^F(\overline{\phi}_{xi}^F)] = f_{ei}(s^F)^{\beta_i}(w^F)^{1-\beta_i} \end{aligned} \tag{2.13}$$

$\delta<1$ is an exogenous probability of a firm's "death" in each period. $1-G(\phi_i^*)$ is the (*ex ante*) probability of successful entry or survival in the domestic market. $\chi_i \equiv \dfrac{1-G(\phi_{xi}^*)}{1-G(\phi_i^*)}$ is the probability for a successful entrant or domestic producer to be an exporter, given that $\phi_{xi}^* > \phi_i^*$. $\pi_i(\overline{\phi}_i)$ is the per-period domestic profit of the averagely productive domestic

[7] I focus only on the case in which exporters are more productive than domestic producers; i.e., $\phi_{xi}^* > \phi_i^*$. The reasons and conditions to be satisfied for this are described in my other paper (Kamata, 2010).

producer, and $\pi_{xi}(\bar{\phi}_{xi})$ is the per-period export profit of the averagely productive exporter. The average productivity levels of domestic producers (or survivors) $\bar{\phi}_i$ and of exporters $\bar{\phi}_{xi}$ are defined, respectively, as follows:

$$\begin{aligned} \bar{\phi}_i(\phi_i^*) &= \left[\frac{1}{1-G(\phi_i^*)}\int_{\phi_i^*}^{\infty}\phi^{\sigma-1}g(\phi)d\phi\right]^{\frac{1}{\sigma-1}} \\ \bar{\phi}_{xi}(\phi_{xi}^*) &= \left[\frac{1}{1-G(\phi_{xi}^*)}\int_{\phi_{xi}^*}^{\infty}\phi^{\sigma-1}g(\phi)d\phi\right]^{\frac{1}{\sigma-1}} \end{aligned} \tag{2.14}$$

The zero-profit conditions (2.10) and (2.11) and the free-entry condition (2.13) jointly determine the two productivity cutoffs, ϕ_i^* and ϕ_{xi}^*, for the respective two countries H and F.

Mass of Firms and Export Varieties

I now examine how many firms in each country will export to the overseas market in each industry. In my model, the number of firms is measured by the size of the "mass" of the continuum of firms. M_i denotes the mass of domestic producers, and M_{ix} denotes the mass of the exporting firms. Only a portion of the domestic producers will be exporters, and that fraction is determined by the two cutoff productivity levels. That is, in equilibrium, the *ex ante* probability for a domestic producer to be an exporter is equal to the *ex post* fraction of exporters among domestic producers, such that:

$$\begin{aligned} \chi_i^H &= M_{xi}^H / M_i^H \Leftrightarrow M_{xi}^H = \chi_i^H \cdot M_i^H \\ \chi_i^F &= M_{xi}^F / M_i^F \Leftrightarrow M_{xi}^F = \chi_i^F \cdot M_i^F \end{aligned} \tag{2.15}$$

Our concern is with the relative size of the exporter mass between the two countries in each industry, M_{xi}^H / M_{xi}^F, and how it will differ across industries in relation to the relative factor intensities of the industries and the relative factor abundance of each country. To derive and examine M_{xi}^H / M_{xi}^F, I consider the equilibrium price indexes of Industry *i* in the two countries, which are composed of the number and average price of domestically produced products, as well as those of products imported from the other country:

$$P_i^H = [M_i^H (p_i^H (\bar{\phi}_i^H))^{1-\sigma} + \chi_i^F \cdot M_i^F (\tau_i \cdot p_i^F (\bar{\phi}_{xi}^F))^{1-\sigma}]^{\frac{1}{1-\sigma}} \tag{2.16}$$

$$P_i^F = [M_i^F (p_i^F (\bar{\phi}_i^F))^{1-\sigma} + \chi_i^H \cdot M_i^H (\tau_i \cdot p_i^H (\bar{\phi}_{xi}^H))^{1-\sigma}]^{\frac{1}{1-\sigma}} \tag{2.17}$$

Dividing Equation (2.16) by (2.17) in both sides yields the following equation:

$$(\frac{P_i^H}{P_i^F})^{1-\sigma} = \frac{M_i^H (p_i^H (\bar{\phi}_i^H))^{1-\sigma} + \chi_i^F \cdot M_i^F \cdot \tau_i^{1-\sigma} (p_i^F (\bar{\phi}_{xi}^F))^{1-\sigma}}{M_i^F (p_i^F (\bar{\phi}_i^F))^{1-\sigma} + \chi_i^H \cdot M_i^H \cdot \tau_i^{1-\sigma} (p_i^H (\bar{\phi}_{xi}^H))^{1-\sigma}} \tag{2.18}$$

By rearranging this equation, we can derive the following expression for the ratio of the masses of domestic producers in the two countries:

$$\frac{M_i^H}{M_i^F} = \frac{(\frac{P_i^H}{P_i^F})^{1-\sigma} (p_i^F (\bar{\phi}_i^F))^{1-\sigma} - \chi_i^F \cdot \tau_i^{1-\sigma} (p_i^F (\bar{\phi}_{xi}^F))^{1-\sigma}}{(p_i^H (\bar{\phi}_i^H))^{1-\sigma} - (\frac{P_i^H}{P_i^F})^{1-\sigma} \cdot \chi_i^H \cdot \tau_i^{1-\sigma} (p_i^H (\bar{\phi}_{xi}^H))^{1-\sigma}} \tag{2.19}$$

By combining Equations (2.15) and (2.19) and rearranging further, we obtain the following expression for the ratio of the exporter masses in the two countries:[8]

$$\frac{M_{xi}^H}{M_{xi}^F} = \frac{\chi_i^H}{\chi_i^F} \cdot \frac{[(\frac{Y^H}{Y^F})(\frac{f_i}{f_{xi}})(\frac{\phi_{xi}^{*F}}{\phi_i^{*F}})^{\sigma-1} - \chi_i^F (\frac{\bar{\phi}_{xi}^F}{\bar{\phi}_i^F})^{\sigma-1}]}{\tau_i^{\sigma-1}[1 - \chi_i^H (\frac{Y^H}{Y^F})(\frac{f_{xi}}{f_i})(\frac{\phi_i^{*H}}{\phi_{xi}^{*H}})^{\sigma-1} (\frac{\bar{\phi}_{xi}^H}{\bar{\phi}_i^H})^{\sigma-1}]} \cdot \left(\frac{p_i^H (\bar{\phi}_i^H)}{p_i^F (\bar{\phi}_i^F)}\right)^{\sigma-1} \tag{2.20}$$

That is, the relative size of the exporter mass in each industry depends on the ratio of (or the "gap" between) the two productivity cutoffs, ϕ_{xi}^* / ϕ_i^*, and the ratio of the average productivity

[8] See Appendix for the derivation of Equation (2.20).

of exporters to that of domestic producers, $\bar{\phi}_{xi} / \bar{\phi}_i$, as well as the ratio of the average domestic price of products between the two countries, $p_i^H(\bar{\phi}_i^H) / p_i^F(\bar{\phi}_i^F)$.

For the purpose of the cross-industry comparison of this relative exporter mass, I impose the following two assumptions:

Assumption 1: $f_i = f_j, f_{ix} = f_{jx}$, and $\tau_i = \tau_j$ for $i \neq j$

Assumption 2: $G(\phi_i) = 1 - \left(\frac{\underline{\phi}_i}{\phi_i} \right)^k$ for i = 1, 2, ….., N; $k > 2\sigma$

The first assumption implies that (i) both fixed costs for production and fixed costs for export, *adjusted for the difference due to factor intensity difference*, are identical across industries; and also that (ii) the "iceberg" shipping cost for export is the same for all industries. The second assumption means that (i) the *ex ante* distribution of firm productivity is common (not only across countries but also) across industries, and that (ii) the distribution is a Pareto distribution with $\underline{\phi}_i$ as the minimum value for productivity drawn in Industry i ($\phi_i \in [\underline{\phi}_i, +\infty)$) and k as a shape parameter indicating the dispersion of productivity distribution.[9] I assume $k > 2\sigma$ for the variances of both drawn productivities and sizes of firms (measured as domestic sales) to be finite.

By examining Equation (2.20) across industries under Assumptions 1 and 2, I derive the following proposition regarding the relative size of the masses of exporters between the two countries.

Proposition: If $\frac{\bar{S}^H}{\bar{U}^H} > \frac{\bar{S}^F}{\bar{U}^F}$ *and* $\beta_i > \beta_j$, *then* $\frac{M_{ix}^H}{M_{ix}^F} > \frac{M_{jx}^H}{M_{jx}^F}$.

Proof: See Appendix.

[9] Chaney (2008) brings some rationale of the use of a Pareto distribution for this type of the model.

This proposition implies that the mass of exporters in a country relative to the mass in the other country will be larger in industries in which the country has a comparative advantage. That is, the relatively skill-abundant country has a larger exporter mass than the other country in a more skill-intensive industry, and *vice versa*.

Can we predict the relative size of the mass of exporters under free trade with FPE? It is well-known that with FPE the cross-industry patterns of production and trade are indeterminate when the number of industries (sectors) is greater than the number of input factors (e.g., Melvin (1968)). This indeterminacy will also apply to our model,[10] and under free trade with FPE there exist multiple equilibrium allocations of the two factors across industries. As an overall tendency, however, the production resources will on average be allocated more to industries in which the country has its comparative advantage (for both factors in the country to be fully employed), so that the mass of firms will *on average* be larger in the comparative advantage industries.

Finally, I present the key prediction for the product varieties in exports. Since each firm is considered to produce a unique variety of differentiated product, the mass of exporting firms in a country, which is examined above, represents the number of product varieties exported from the country in each industry. Therefore, the above Proposition has the following implication on export varieties, which is expressed as the following prediction:

> *Prediction: For a certain pair of countries, international trade will exhibit the following cross-industry pattern: The relatively skilled-labor abundant country will export more product varieties in more skill -intensive industries*

[10] We can see this indeterminacy in the relative size of the mass of exporters in Equation (2.19). Under free trade with FPE, $\tau_i = 1$, $\chi_i = 1$ (since all active firms will be exporters), the price of a product variety will be the same in the two market, and the industry price index will be equal in the two countries. Hence, both numerator and denominator of the right-hand side of the equation is zero, which implies the indeterminacy of M_i^H/M_i^F.

(industries with greater β). In contrast, the relatively unskilled- labor abundant country will export more varieties in more unskilled-labor intensive industries (industries with smaller β).

3. The Data

An empirical test of the prediction of my model requires data for three variables: the number of product varieties exported from each country in each industry, factor endowment in each exporting country, and factor intensity in each industry.

For the product varieties in exports, I use the data on the U.S. imports in the years of 1990, 1995, and 2000 that are from Feenstra, Romalis, and Schott (2002). The data contain information on the U.S. imports of each good classified according to the disaggregated ten-digit Harmonized System (HS) exported from each country. The data also map each ten-digit HS code onto different and more aggregated industry classifications such as the four-digit U.S. Standard Industrial Classification (SIC, the 1987 version) and the six-digit North American Industry Classification System (NAICS, the 1997 version). These different levels of classification in the data enable me to count the number of product varieties in each industry by defining "products" or "varieties" according to the ten-digit HS and "industries" according to the four-digit SIC or six-digit NAICS.[11] Due to the limitation of the availability of the data on industry factor intensity, my empirical analysis focuses on trade in manufacturing industries (the codes 2011 through 3999 in the four-digit SIC, and 311111 through 339999 in the six-digit NAICS). Table 1 provides the numbers of exporters, numbers of product varieties, and total import values in the U.S. total imports and manufacturing imports in each of the three years. In these three years, manufacturing industries represent 94% of the total

[11] See the following section for further details.

U.S. imports in terms of the number of product varieties, and 83% through 86% in terms of value.

The data for the factor endowment of each country are from Hall and Jones (1999). Since the theoretical model is embedded in a two-factor framework with skilled labor (S) and unskilled labor (U), I use the data on human capital per worker as the measure of the abundance of skilled labor relative to unskilled labor (S/U) in each country. The data on human capital per worker are estimated as of 1988 and available for 127 countries in their study.

The theoretical model assumes a common factor intensity for each industry across countries. To measure this world common factor intensity of each industry, I use the data from the U.S. Census of Manufactures for the years of 1992, 1997, and 2002. The 1992 census applies the U.S. SIC (1987 version), while the 1997 and 2002 censuses use NAICS to classify manufacturing industries.[12] For each classified industry, the censuses report the number of production workers (average per worker) separately from the total employment. Therefore, I measure industry *un*skilled-labor intensity as the share of production workers in the total employment, and accordingly skilled-labor intensity as the share of non-production workers (i.e., one minus unskilled-labor intensity). I thus obtain the skill intensities for 458 four-digit SIC industries from the 1992 census that are combined with the U.S. import data for 1990, and the skill intensities for 473 six-digit NAICS industries from the 1997 and 2002 censuses that are combined with the 1995 and 2000 import data, respectively.

The data for my empirical analysis includes 115 countries whose factor endowment measure is available in Hall and Jones (1999) and from which the U.S. imported in any one or

[12] NAICS has been modified for the 2002 census (2002 version) from the previous 1997 version. However, for manufacturing industries, the two versions are identical.

more manufacturing industry in the years 1990, 1995, and 2000.[13] Table 2 lists these 115 countries, and Table 3 provides the summary statistics of the relative factor endowment (the skilled-labor to unskilled-labor ratio: S/U) of these countries with the lists of the ten most and least skilled labor-abundant countries. The data also include 394 (four-digit SIC) manufacturing industries for 1990, and 383 and 384 (six-digit NAICS) industries for 1995 and 2000, respectively, in which the U.S. imported from one or more countries in each year. Tables 4.1 through 4.3 present the summary statistics of the intensities of the two factors (S and U) of these manufacturing industries, as well as the ten most and least skilled-labor intensive industries, for the three respective years.

Figures 1.1 through 1.3 display the number of countries from which the U.S. imported in each manufacturing industry for each year. In each table, the industries are sorted (from left to right) in the order of skilled-labor intensity. Figures 2.1 through 2.3 and 3.1 through 3.3 plot the number of exporting countries and the total number of product varieties in the U.S. imports in each industry, respectively, against the industry skilled-labor intensity. These figures indicate that the U.S., one of the world's most skilled-labor abundant countries, tended to import more varieties from more countries in relatively unskilled-labor intensive industries, while the U.S. has increased imports in relatively skill intensive industries and thus the trend has become unclear in recent years.

4. Empirical Tests

As stated in Section 2, the theoretical model provides one key prediction: A country will export more varieties of products in industries in which the country has a comparative

[13] Of the 115 countries, the following three countries are included only in the data for 1990: Czechoslovakia, the U.S.S.R., and Yugoslavia.

advantage, in terms of factor proportions, than it will in other industries. In this section I empirically test this implication using the data described in the previous section.

Measuring Exported Varieties

The model explains the number of product varieties in each industry that are exported from each country to a common importer—in this case, the U.S.— in terms of two elements: the relative factor abundance of the exporting country and the relative factor intensity of the industry. As described in the previous section, I define a variety as each ten-digit HS good and an industry as each four-digit SIC (for 1990) or six-digit NAICS (for 1997 and 2000). I thus measure the number of product varieties in Industry i exported from Country c, or n_{ic}, as follows:

$$n_{ic} \equiv \text{No. of ten-digit HS goods exported from Country c in a four-digit SIC or six-digit NAICS Industry } i$$

Some four-digit SIC or six-digit NAICS industries may contain by nature more ten-digit HS goods in their catalogue than other industries, and thus in the U.S. imports we may observe more varieties in those industries than in other industries, regardless of the role of the comparative advantage. Therefore, for a proper cross-industry comparison, I use the following normalized measure for the number of varieties:[14]

$$n\_share_{ic} = \frac{n_{ic}}{N_i}$$

[14] This variable is consistent with the idea of the "relative size of firm mass" described in Proposition in Section 2. Here, due to the limitation of the employed data, the number of exported varieties from one country in one industry is expressed as the relative value to the number of varieties exported from the rest of the world in that industry, instead of the ratio to the number of varieties exported from the trading partner (i.e., the U.S.).

where N_i is the total number of varieties that the U.S. imports from the world in industry i: $N_i = \sum_c n_{ic}$.[15] It should be noted that the imports of the same 10-digit commodities from different countries are considered as different product varieties, following the theoretical assumption that products are differentiated across firms and thus across countries.

Regressions for Aggregate North and South

I first test our two-country, two-factor, and multi-industry model with the data for country aggregates. I divide the 115 countries into two groups to construct two country aggregates, one of which consists of countries that are relatively skilled-labor abundant (or with high S/U). I refer to this group as the "North." The other consists of countries that are relatively unskilled-labor abundant (or with low S/U), which I call the "South." The North consists of 51 countries whose S/U is above the average of all the 115 countries, and the South comprises other 64 countries.[16] Table 5 lists the names of the countries constituting each of the aggregates North and South. Table 6 compares the within-group averages of relative factor abundance S/U.

The following equation is estimated using the OLS for the aggregate North and South:[17]

$$log(n\_share_{i,A}) = \gamma + \theta \cdot skill_i + \varepsilon_i \tag{4.1}$$

[15] Accordingly, the total number of varieties in each industry, N_i, includes the number of varieties exported to the U.S. from countries other than 115 countries in the sample.
[16] I also attempted the following two other "cutoffs" for S/U to divide the countries into the aggregates North and South: above or below the 75 percentile (29 countries in the North, 86 in the South), and above or below 0.7 relative to S/U of the U.S. (25 countries in the North, 90 in the South). These alternative groupings are also indicated in Table 5. The qualitative results of the estimation, however, are the same regardless of the cutoffs.
[17] n_share_{ic} is skewed in distribution, and therefore scaled to logarithm for the regressions to adjust for potential heteroskedasticity. I do not scale the factor intensity measure ($skill_i$) to logarithm, but the results do not change even though the log-scaled intensity is used.

where $n\_share_{i,A} = \sum_{c \in A} n\_share_{i,A}$, A = {North, South}

$skill_i$ = skill intensity of Industy i.

Equation (4.1) is estimated for the three respective years. The result of the estimation is shown in Table 7. For all the three years, the result is consistent with the prediction of the model. That is, the estimated coefficient for the industry skill intensity is positive for the North, indicating that the relatively skilled-labor abundant North exports more varieties in more skill-intensive industries; and the coefficient estimate is negative for the South, which implies that in the relatively unskilled-labor abundant South the number of varieties in exports is higher as the industry is less skill intensive (or more *un*skilled-labor intensive). The result of the analysis for the country aggregates thus supports the quasi-Heckscher-Ohlin prediction of the model about the product varieties in exports.[18]

Pooled Regression for Dependent Parameter Specification

I next use the pooled data for all the individual exporting countries to estimate cross-industry patterns of exports in terms of product varieties. I consider the following regression model:

$$log(n\_share_{ic}) = \gamma + \Pi_c \cdot skill_i + \varepsilon_{ic} \qquad (4.2)$$

The slope coefficient for skilled-labor intensity, Π_c, would differ across exporter countries. The theory predicts that the value of the slope coefficient will be higher for countries with greater relative endowment of skilled labor, and lower for countries with smaller relative skilled labor endowment (or greater relative endowment of unskilled labor). This pattern is

[18] The level of significance is not very high for the estimate for the North in the year 2000. This should be because, as shown in Figures 1.3, 2.3, and 3.3, in recent years the U.S. imports from more countries in relatively skill-intensive industries. However, the estimate is more significant (at the 1% level) when the alternative cutoffs are applied to group the North and South.

indeed observed in the result of the estimation of Equation (4.2) for each individual exporting country. Figures 4.1 through 4.3 plot the slope coefficient $\hat{\Pi}_c$ estimated from each individual country regression against the relative skilled-labor abundance of the country (in logarithmic scale, log(S/U)). The figures exhibit the tendency that the coefficient Π_c is greater for a more skill-abundant country, which is consistent across years.[19] To confirm this pattern in the pooled regression, we impose the following structure on the slope coefficient Π_c:

$$\Pi_c = \Pi((S/U)_c) = \theta_1 + \theta_2 \cdot \log(S/U)_c \tag{4.3}$$

where $(S/U)_c$ is the skilled- to unskilled-labor ratio of Country c.[20] The theoretical prediction is that θ_1 will be negative (since Π_c will be negative for countries with low skilled-labor abundance) and θ_2 will be positive (since Π_c will be larger and to be positive for countries with higher skilled-labor abundance). By substituting (4.3) into (4.2), I derive the following equation for our pooled regression:

$$log(n\_share_{ic}) = \theta_1 \cdot skill_i + \theta_2 \cdot skill_i \cdot \log(S/U)_c + \mu_c + \varepsilon_{ic} \tag{4.4}$$

I include country dummies, μ_c, to capture the effects of all country-specific factors other than the relative factor abundance, such as fixed and variable trade costs (of importing to the U.S.) and the size of the country.

Table 8 presents the result of the estimation of Equation (4.4) for each of the years 1990, 1995, and 2000 using the fixed-effect OLS. The estimates of both coefficients θ_1 and θ_2 have the signs that are expected from the theory, and they are highly significant (at the 1%

[19] To draw the fitted line in Figures 4.1 through 4.3, the cases (i.e., the results of individual country regressions) are weighted by the number of observations (i.e., the number of industries for each country in the data) in each individual country regression.
[20] I use the logarithm of the relative skill abundance to have the size of the coefficient estimate for θ_2 invariant to which of S or U is on the denominator.

level).[21] This result is consistent across years. Hence, the quasi-Heckscher-Ohlin prediction of our economic model on the exported varieties is also supported by the pooled analysis using the U.S. import data.

Finally, using these estimates I compute the "threshold" factor abundant at which the country-specific slope coefficient for skill intensity Π_c turns from negative to positive (i.e., S/U^* such that $\Pi_c(S/U^*) = 0$). The value of the "threshold" S/U^* is 2.11 for the year 1990,[22] which is the closest to the relative factor abundance in China (S/U = 2.09, the 39th most skilled-abundant) among the 115 countries. The threshold S/U^* is 2.25 for 1995, which is the closest to S/U in Greece (=2.25, the 29th out of 115); and is 2.32 for 2000 that is the closest to S/U in Taiwan (=2.31, the 26th). These values for the skill abundance can be interpreted as the cutoff to divide countries into the North and South for the respective years, which is more accurate than the cutoff value used in the previous subsection to divide the countries into the two groups.[23]

Alternative Measure of Export Varieties

For checking the robustness of the results of our empirical tests, I also employ an alternative measure of product varieties in countries' exports that are frequently used in literature. Following Feenstra and Kee (2004a) and Hummels and Klenow (2005),[24] as an alternative to our original measure of export varieties n_share_{ic}, I use the following measure

[21] This result does not change when the natural-scaled measure of S/U is used in the regression instead of log(S/U); i.e., $\hat{\theta}_1$ is negative and $\hat{\theta}_2$ is positive, both significant at the 1% level.

[22] $S/U^* = \exp(-\frac{\hat{\theta}_1}{\hat{\theta}_2}) = \exp(-\frac{-1.80}{2.42}) \approx 2.10$. The value is also computed for the years 1995 and 2000 in the same way.

[23] The average (S/U) of the 115 countries that is used as the cutoff in the previous subsection is 1.88, which is a little lower than these values.

[24] Broda and Weinstein (2006) also employ this measure of "relative variety."

of “relative product variety” (Hummels & Klenow use the term of the “extensive margin”) in a country’s export:

$$RV_{ic} \equiv \frac{\sum_{\omega \in \Omega_i^c} p_\omega^* x_\omega^*}{\sum_{\omega \in \Omega_i^*} p_\omega^* x_\omega^*}$$

The asterisk * denotes the “benchmark country” for comparison, which is the aggregate of all countries in the world.[25] ω denotes a ten-digit HS good; Ω_i^c is a subset of ten-digit HS goods belonging to Industry i (defined by the four-digit SIC or six-digit NAICS) that are exported from a particular country c to the U.S.; and Ω_i^* is a whole set of all the ten-digit HS goods in Industry i that are exported to the U.S. from all countries (other than the U.S. itself) in the world. p_ω^* and x_ω^* are the price and quantity of Product ω exported by the “benchmark country” (i.e., $p_\omega^* x_\omega^*$ is the value of the exports of Product ω from the world country aggregate to the U.S.).[26]

I replace the dependent variable in Equation (4.4) for the pooled regression with this alternative measure of “relative variety” RV_{ic}, both in the natural scale and logarithm, and estimate the following resulted equations for each of the years 1990, 1995, and 2000 using the fixed-effect OLS with country dummies (μ_c):

$$RV_{ic} = \theta_1 \cdot skill_i + \theta_2 \cdot skill_i \cdot \log(S/U)_c + \mu_c + \varepsilon_{ic} \tag{4.5}$$

$$\log(RV_{ic}) = \theta_1 \cdot skill_i + \theta_2 \cdot skill_i \cdot \log(S/U)_c + \mu_c + \varepsilon_{ic} \tag{4.6}$$

The results are shown in Table 9. In both Equations (4.5) and (4.6), the estimate of the coefficient θ_1 is negative and the estimate of θ_2 is positive, both of which are significant at the

[25] This “benchmark” world aggregate includes countries other than the 115 countries in my data.
[26] Note that this RV_{ic} is a value-based measure while my original measure n_share_{ic} is based on number counting. However, the two measures are similar in the sense that both define industries by the four-digit SIC or six-digit NAICS and product varieties by the ten-digit HS.

1% level, throughout the years. The results are consistent with the prediction from the theoretical model as the result in the previous subsection is, and thus confirm that the result of the empirical test is robust across measures of export varieties.

5. Conclusion

In this paper, I have investigated the relationship between export varieties and the exporting country's comparative advantage in terms of factor proportions. I have generalized the heterogeneous-firm models by Melitz (2003) and Bernard, Redding, and Schott (2007) to the framework with a multitude of industries, and have derived a prediction that relates product varieties in a country's exports to the relative factor intensity of exported industries. To test the prediction I have employed the disaggregated data on the U.S. imports, as well as the data on skill abundance in countries and the skill intensities of manufacturing industries. The results of a variety of empirical tests provide strong evidence for the model's quasi-Heckscher-Ohlin prediction: countries tend to export more varieties of products in industries in which they have their respective comparative advantages.

References

[1] Chaney, T. (2008), "Distorted Gravity: The Intensive and Extensive Margins of International Trade," *American Economic Review*, Vol. 98, No. 4, pp. 1707-1721

[2] Choi, Y. C., D. Hummels, and C. Xiang (2006), "Explaining Import Variety and Quality: the Role of the Income Distribution," NBER Working Paper No. 12531

[3] Bernard, A. B., S. J. Redding, and P. K. Schott (2007), "Comparative Advantage and Heterogeneous Firms," *Review of Economic Studies*, Vol. 74, No. 1, pp. 31-66

[4] Broda, C. and D. E. Weinstein (2004), "Variety Growth and World Welfare," *American Economic Review*, Vol. 94, No. 2, pp. 139-144

[5] Davis, D. R. and D. E. Weinstein (2003), "Market Access, Economic Geography, and Comparative Advantage: An Empirical Assessment," *Journal of International Economics*, Vol. 59, No. 1, pp. 1-23

[6] Davis, D. R. and D. E. Weinstein (2001), "An Account of Global Factor Trade," *American Economic Review*, Vol. 91, No. 5, pp. 1423-1453

[7] Debaere, P. and S. Mostashari (2010), "Do Tariffs Matter for the Extensive Margin of International Trade? An Empirical Analysis," *Journal of International Economics*, Vol. 81, No. 2, pp. 163-169

[8] Dixit, A. K. and V. Norman (1980), *Theory of International Trade*, Cambridge University Press, Cambridge, U.K.

[9] Dornbusch, R., S. Fischer, and P. A. Samuelson (1980), "Heckscher-Ohlin Trade Theory with a Continuum of Goods," *Quarterly Journal of Economics*, Vol. 95, No. 2, pp. 823-839

[10] Falvey, R. E. and H. Kierzkowski (1987), "Product Quality, Intra-industry Trade and Imperfect Competition," Kierzkowski, H., *eds.*, *Protection and Competition in International Trade: Essays in Honor of W. M. Corden*, Basil Blackwell, Oxford and London, U.K.

[11] Feenstra, R. C. (1994), "New Product Varieties and the Measurement of International Prices," *American Economic Review*, Vol. 84, No. 1, pp. 157-177

[12] Feenstra, R. C. and H. L. Kee (2004a), "On the Measurement of Product Variety in Trade," *American Economic Review*, Vol. 94, No. 2, pp. 145-149

[13] Feenstra, R. C. and H. L. Kee (2004b), "Export Variety and Country Productivity," World Bank Policy Research Working Paper 3412

[14] Feenstra, R. C. and H. L. Kee (2008), "Export Variety and Country Productivity: Estimating the Monopolistic Competition Model with Endogenous Productivity," *Journal of International Economics*, Vol. 74, No. 2, pp. 500-518

[15] Feenstra, R. C., J. Romalis and P. K. Schott (2002), "U.S. Imports, Exports, and Tariff Data, 1989-2001," NBER Working Paper No. 9387

[16] Feenstra, R. C., T. H. Yang, and G. G. Hamilton (1999), "Business groups and product variety in trade: evidence from South Korea, Taiwan and Japan," *Journal of International Economics*, Vol. 48, No. 1, pp. 71-100

[17] Funke, M. and R. Ruhwedel (2001a), "Product Variety and Economic Growth: Empirical Evidence for the OECD Countries," IMF Staff Papers, Vol. 48, No. 2

[18] Funke, M. and R. Ruhwedel (2001b), "Export Variety and Export Performance: Empirical Evidence for East Asia," *Journal of Asian Economics*, Vol. 12, No. 4, pp. 493-505

[19] Funke, M. and R. Ruhwedel (2005), "Export Variety and Economic Growth in East European Transition Economies," *Economics of Transition*, Vol. 13, No. 1, pp. 25-50

[20] Hall, R. E. and C. I. Jones (1999), "Why Do Some Countries Produce So Much More Output Per Worker Than Others?", *Quarterly Journal of Economics*, Vol. 114, No. 1, pp. 83-116

[21] Hallak, J. C. (2006a), "Product Quality and the Direction of Trade," *Journal of International Economics*, Vol. 68, No. 1, pp. 238-265

[22] Hallak, J. C. (2006b), "A Product-Quality View of the Linder Hypothesis," NBER Working Paper No. 12712

[23] Helpman, E. and P. R. Krugman (1985), *Market Structure and Foreign Trade*, MIT Press, Cambridge, M.A.

[24] Hummels, D. and P. J. Klenow (2005), "The Variety and Quality of A Nation's Trade," *American Economics Review*, Vol. 95, No. 3, pp. 704-723

[25] Hummels, D. and V. Lugovskyy (2005), "Trade in Ideal Varieties: Theory and Evidence," NBER Working Paper No. 11828

[26] Kamata, I. (2010), "Comparative Advantage, Firm Heterogeneity, and Selection of Exporters," La Follette School Working Paper No. 2010-005

[27] Kehoe, T. J. and K. J. Ruhl (2003), "How Important is the New Goods Margin in International Trade?", Federal Reserve Bank of Minneapolis Research Department Staff Report 324

[28] Krugman, P. R. (1979), "Increasing Returns, Monopolistic Competition, and International Trade," *Journal of International Economics*, Vol. 9, No. 4, pp. 469-479

[29] Melitz, M. J. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, Vol. 71, No. 6, pp. 1695-1725

[30] Melvin, J. R. (1968), "Production and Trade with Two Factors and Three Goods," *American Economic Review*, Vol. 58, No. 5, pp. 1249-1268

[31] Romalis, J. (2004), "Factor Proportions and the Structure of Commodity Trade," *American Economic Review*, Vol. 94, No. 1, pp. 67-97

[32] Samuelson, P. A. (1949), "International Factor-Price Equalization Once Again," *Economic Journal*, Vol. 59, No. 234, pp. 181-197

[33] Schott, P. K. (2003), "One Size Fits All? Heckscher-Olin Specialization in Global Production," *American Economic Review*, Vol. 93, No.3, pp. 686-708

[34] Schott, P. K. (2004), "Across-Product versus Within-Product Specialization in International Trade," *Quarterly Journal of Economics*, Vol. 119, No. 2, pp. 647-678

Appendix

1. Derivation of Equations (2.20):

By combining the revenue equations (2.7) and (2.8) and the zero-profit conditions (2.10) and (2.11), we can derive the following equations for the ratio of the two productivity cutoffs for each of Home and Foreign:

$$\frac{\phi_{xi}^{*H}}{\phi_i^{*H}} = \tau_i \left(\frac{P_i^H}{P_i^F}\right)\left(\frac{Y^H}{Y^F} \cdot \frac{f_{xi}}{f_i}\right)^{\frac{1}{\sigma-1}} \tag{A.1}$$

$$\frac{\phi_{xi}^{*F}}{\phi_i^{*F}} = \tau_i \left(\frac{P_i^F}{P_i^H}\right)\left(\frac{Y^F}{Y^H} \cdot \frac{f_{xi}}{f_i}\right)^{\frac{1}{\sigma-1}} \tag{A.2}$$

The ratio of the industry price indexes in the two countries can be derived, by rearranging the Equations (A.1) and (A.2), as follows:

$$\frac{P_i^H}{P_i^F} = \tau_i^{-1}\left(\frac{\phi_{xi}^{*H}}{\phi_i^{*H}}\right)\left(\frac{Y^F}{Y^H}\right)^{\frac{1}{\sigma-1}}\left(\frac{f_i}{f_{xi}}\right)^{\frac{1}{\sigma-1}} = \tau_i\left(\frac{\phi_i^{*F}}{\phi_{xi}^{*F}}\right)\left(\frac{Y^F}{Y^H}\right)^{\frac{1}{\sigma-1}}\left(\frac{f_{xi}}{f_i}\right)^{\frac{1}{\sigma-1}} \tag{A.3}$$

Substituting this Equation (A.3) to Equation (2.19) and re-arranging yields the following:

$$\frac{M_i^H}{M_i^F} = \frac{\tau_i^{1-\sigma}\left[\left(\frac{Y^H}{Y^F}\right)\left(\frac{f_i}{f_{xi}}\right)\left(\frac{\phi_i^{*F}}{\phi_{xi}^{*F}}\right)^{1-\sigma}\left(p_i^F(\bar{\phi}_i^F)\right)^{1-\sigma} - \chi_i^F\left(p_i^F(\bar{\phi}_{xi}^F)\right)^{1-\sigma}\right]}{\left(p_i^H(\bar{\phi}_i^H)\right)^{1-\sigma} - \chi_i^H\left(\frac{Y^H}{Y^F}\right)\left(\frac{f_{xi}}{f_i}\right)\left(\frac{\phi_{xi}^{*H}}{\phi_i^{*H}}\right)^{1-\sigma}\left(p_i^H(\bar{\phi}_{xi}^H)\right)^{1-\sigma}} \tag{A.4}$$

The optimal pricing equation (2.5) implies that the ratio of the prices charged by two firms with different productivity *in the same market* can be expressed as the ratio of the two productivities, i.e.:

$$p_i(\phi') = \left(\frac{\phi}{\phi'}\right) \cdot p_i(\phi) \tag{A.5}$$

Using this, the price charged by a firm with the average exporter productivity *in the domestic market* is expressed, using the average price of domestic producers, as follows:

$$p_i^H(\bar{\phi}_{xi}^H) = (\frac{\bar{\phi}_i^H}{\bar{\phi}_{xi}^H}) \cdot p_i^H(\bar{\phi}_i^H) \tag{A.6}$$

$$p_i^F(\bar{\phi}_{xi}^F) = (\frac{\bar{\phi}_i^F}{\bar{\phi}_{xi}^F}) \cdot p_i^F(\bar{\phi}_i^F) \tag{A.7}$$

Substituting these equations (A.6) and (A.7) into Equation (A.4) and re-arranging the terms yields the following expression for the relative size of the masses of domestic producers:

$$\frac{M_i^H}{M_i^F} = \frac{[(\frac{Y^H}{Y^F})(\frac{f_i}{f_{xi}})(\frac{\phi_{xi}^{*F}}{\phi_i^{*F}})^{\sigma-1} - \chi_i^F(\frac{\bar{\phi}_{xi}^F}{\bar{\phi}_i^F})^{\sigma-1}]}{\tau_i^{\sigma-1}[1-\chi_i^H(\frac{Y^H}{Y^F})(\frac{f_{xi}}{f_i})(\frac{\phi_i^{*H}}{\phi_{xi}^{*H}})^{\sigma-1}(\frac{\bar{\phi}_{xi}^H}{\bar{\phi}_i^H})^{\sigma-1}]} \cdot \left(\frac{p_i^H(\bar{\phi}_i^H)}{p_i^F(\bar{\phi}_i^F)}\right)^{\sigma-1} \tag{A.8}$$

Equation (2.20) is derived from this (A.8) and Equation (2.15).

2. Proof of Proposition:

Without the loss of generality, Industry i is assumed to be more skill intensive than Industry j ($\beta_i > \beta_j$). Then, from my other paper (Kamata, 2010), the relationship of the probability for a domestic producer to be an exporter between the two industries is: $\chi_i^H > \chi_j^H$ for the relatively skill abundant Home; and $\chi_i^F < \chi_j^F$ for the relatively unskilled-labor abundant Foreign.

These two inequalities is equivalent to the following inequality:

$$\frac{\chi_i^H}{\chi_i^F} > \frac{\chi_j^H}{\chi_j^F} \tag{A.9}$$

Recall now Equation (2.20) for the relative exporter mass:

$$\frac{M_{xi}^H}{M_{xi}^F} = \frac{\chi_i^H}{\chi_i^F} \cdot \frac{[(\frac{Y^H}{Y^F})(\frac{f_i}{f_{xi}})(\frac{\phi_{xi}^{*F}}{\phi_i^{*F}})^{\sigma-1} - \chi_i^F (\frac{\overline{\phi}_{xi}^F}{\overline{\phi}_i^F})^{\sigma-1}]}{\tau_i^{\sigma-1}[1-\chi_i^H (\frac{Y^H}{Y^F})(\frac{f_{xi}}{f_i})(\frac{\phi_i^{*H}}{\phi_{xi}^{*H}})^{\sigma-1} (\frac{\overline{\phi}_{xi}^H}{\overline{\phi}_i^H})^{\sigma-1}]} \cdot \left(\frac{p_i^H(\overline{\phi}_i^H)}{p_i^F(\overline{\phi}_i^F)} \right)^{\sigma-1}$$

Let us rewrite this as follows:

$$\frac{M_{ix}^H}{M_{ix}^F} = (\frac{\chi_i^H}{\chi_i^F}) \cdot \frac{A_i}{\tau_i^{\sigma-1} \cdot B_i} \cdot \left(\frac{p_i^H(\overline{\phi}_i^H)}{p_i^F(\overline{\phi}_i^F)} \right)^{\sigma-1} \qquad \text{(A.10)}$$

where $A_i \equiv (\frac{Y^H}{Y^F})(\frac{f_i}{f_{xi}})(\frac{\phi_{xi}^{*F}}{\phi_i^{*F}})^{\sigma-1} - \chi_i^F (\frac{\overline{\phi}_{xi}^F}{\overline{\phi}_i^F})^{\sigma-1}$ and $B_i \equiv 1-\chi_i^H (\frac{Y^H}{Y^F})(\frac{f_{xi}}{f_i})(\frac{\phi_i^{*H}}{\phi_{xi}^{*H}})^{\sigma-1} (\frac{\overline{\phi}_{xi}^H}{\overline{\phi}_i^H})^{\sigma-1}$.

The relative exporter mass thus depends on the ratio of the fractions of exporters among active firms in the two countries (χ_i^H / χ_i^F), the terms A_i and B_i, and the relative average price of domestic products in the two countries ($p_i^H(\overline{\phi}_i^H) / p_i^F(\overline{\phi}_i^F)$). Let us first examine these four factors separately.

- $\frac{\chi_i^H}{\chi_i^F}$ vs $\frac{\chi_j^H}{\chi_j^F}$: As shown in the inequality (A.9), $\frac{\chi_i^H}{\chi_i^F} > \frac{\chi_j^H}{\chi_j^F}$.
- A_i vs A_j: As shown in my other paper (Kamata, 2010), the ratio of (or the "gap" between) the two productivity cutoffs is larger in the country's comparative *dis*advantage industry. Therefore, for the relatively skill-scarce Foreign, $\frac{\phi_{xi}^{*F}}{\phi_i^{*F}} < \frac{\phi_{xj}^{*F}}{\phi_j^{*F}}$.

  Hence, with Assumption 1, the first term is larger in A_i than A_j.

  To examine the second term, I first consider the ratio of the two productivity averages, $\frac{\overline{\phi}_{xi}}{\overline{\phi}_i}$. From Assumption 2, the productivity distribution is the same across industries and has a Pareto form. Therefore, by substituting the Pareto density function in Assumption 2 into the definition of these productivity averages (2.14), and with some algebra, we can show that the ratio of the two productivity averages is indeed equal to the ratio of the two productivity cutoffs; i.e., $\frac{\bar{\phi}_{xi}}{\bar{\phi}_i} = \frac{\phi^*_{xj}}{\phi^*_j}$. In addition, the Pareto assumption implies that $\chi_i = \left(\frac{\phi^*_{xi}}{\phi^*_i}\right)^{-k}$. Thus, the second term of A_i equals $\left(\frac{\phi^*_{xi}}{\phi^*_i}\right)^{-(1+k-\sigma)}$ while the second term of A_j equals $\left(\frac{\phi^*_{xj}}{\phi^*_j}\right)^{-(1+k-\sigma)}$. Hence, for the skill-scarce Foreign, the second term is smaller in A_i than in A_j (i.e, $\frac{\phi^{*F}_{xi}}{\phi^{*F}_i} > \frac{\phi^{*F}_{xj}}{\phi^{*F}_j} \Leftrightarrow \left(\frac{\phi^{*F}_{xi}}{\phi^{*F}_i}\right)^{-(1+k-\sigma)} < \left(\frac{\phi^*_{xj}}{\phi^*_j}\right)^{-(1+k-\sigma)}$).

These relationship of the two terms implies $A_i > A_j$.

- B_i vs B_j: Using the equalities $\frac{\bar{\phi}_{xi}}{\bar{\phi}_i} = \frac{\phi^*_{xj}}{\phi^*_j}$ and $\chi_i = \left(\frac{\phi^*_{xi}}{\phi^*_i}\right)^{-k}$ that are implied by Assumption 2, we obtain $B_i = 1 - \chi^H_i (\frac{Y^H}{Y^F})(\frac{f_{xi}}{f_i})$ and $B_j = 1 - \chi^H_j (\frac{Y^H}{Y^F})(\frac{f_{xj}}{f_j})$. Since Assumption 1 implies $\frac{f_{xi}}{f_i} = \frac{f_{xj}}{f_j}$, $\chi^H_i > \chi^H_j$ indicates $B_i < B_j$.

- $\frac{\bar{p}^H_i}{\bar{p}^F_i}$ vs $\frac{\bar{p}^H_j}{\bar{p}^F_j}$: From the optimal pricing Equation (2.5), the relative average price depend on two factors: the ratio of the average productivity of active firms in the two countries, and the relative factor prices. The relative average price takes the following form:

$$\frac{\bar{p}^H_i}{\bar{p}^F_i} = (\frac{\bar{\phi}^F_i}{\bar{\phi}^H_i})\left\{\left(\frac{s^H / w^H}{s^F / w^F}\right)^{\beta_i}\left(\frac{w^H}{w^F}\right)\right\} \qquad \text{(A.11)}$$

The second term of the right-hand side of (A.11) is smaller for Industry i since $\frac{s^H}{w^H} < \frac{s^F}{w^F}$ (see Kamata, 2010 for the proof) and $\beta_i > \beta_j$. The first term equals one since I assume a common productivity distribution across countries, which implies that $\bar{\phi}_i^H = \bar{\phi}_i^F$. Hence, the relative price follows the comparative advantages of the countries; i.e., $\frac{\bar{p}_i^H}{\bar{p}_i^F} < \frac{\bar{p}_j^H}{\bar{p}_j^F}$.

From these results of the four elements in Equation (A.10), it is shown that $\frac{M_{ix}^H}{M_{ix}^F} > \frac{M_{jx}^H}{M_{jx}^F}$, which implies that each country has a larger mass of exporters in its comparative advantage industries relative to the other country. ■

Table 1: U.S. Imports and Varieties

		Total Import	Manufacturing Import
Number of Exporting Countries	1990	153	153
	1995	169	169
	2000	174	173
Number of Varieties	1990	182,375	171,322
	1995	219,329	206,334
	2000	259,181	243,598
Total Import Value (in million $)	1990	495,260	409,953
	1995	743,505	643,128
	2000	1,216,888	1,024,664

Notes:

1. The data are from Feenstra, Romalis, and Schott (2002).
2. Manufacturing imports are the imports in the industries classified as the 4-digit 1987 U.S. SIC 2011 through 3999 (for 1990) or the 6-digit NAICS 311111 through 339999 (for 1995 and 2000).
3. Exporting countries in this table include overseas territories of countries.
4. The number of varieties is defined as the number of goods classified by the 10-digit Harmonization System (HS) that the U.S. imports *from each exporter*. (I.e., the same 10-digit HS goods imported from different exporters are counted as different varieties.)
5. Import value is the customs value of general imports. "General Imports measure the total physical arrivals of merchandise from foreign countries, whether such merchandise enters consumption channels immediately or is entered into bonded warehouses or Foreign Trade Zones under Customs custody" (U.S. International Trade Administration).

Table 2: Country List (115 countries)

Algeria	Guinea	Peru
Angola	Guinea-Bissau	Philippines
Argentina	Guyana	Poland
Australia	Haiti	Portugal
Austria	Honduras	Reunion
Bangladesh	Hong Kong	Rwanda
Barbados	Hungary	Saudi Arabia
Belgium	Iceland	Senegal
Benin	India	Seychelles
Bolivia	Indonesia	Sierra Leone
Brazil	Iran	Singapore
Burkina Faso	Ireland	Somalia
Burundi	Israel	South Africa
Cameroon	Italy	South Korea
Canada	Jamaica	Spain
Central African Republic	Japan	Sri Lanka
Chad	Jordan	Sudan
Chile	Kenya	Suriname
China	Madagascar	Sweden
Colombia	Malawi	Switzerland
Congo	Malaysia	Syria
Costa Rica	Mali	Taiwan
Cote d'Ivoire	Malta	Tanzania
Cyprus	Mauritania	Thailand
Czechoslovakia*	Mauritius	Togo
Denmark	Mexico	Trinidad and Tobago
Dominican Republic	Morocco	Tunisia
Ecuador	Mozambique	Turkey
Egypt	Netherlands	U.S.S.R.*
El Salvador	New Zealand	Uganda
Fiji	Nicaragua	United Kingdom
Finland	Niger	Uruguay
France	Nigeria	Venezuela
Gabon	Norway	Yugoslavia*
Gambia	Oman	Zaire
Germany	Pakistan	Zambia
Ghana	Panama	Zimbabwe
Greece	Papua New Guinea	
Guatemala	Paraguay	

Note: The data for Years 1995 and 2000 do not include three countries marked with an asterisk (*).

Table 3: Factor Abundance of Countries: Skilled Labor (*S*) to Unskilled Labor (*U*) Ratio

Summary Statistics:

Variables	Mean	Std. Dev.	Min.	Max.
S/U	1.879	0.553	1.075	3.369
$\log(S/U)$	0.589	0.290	0.072	1.215

Number of countries: 115

10 most skilled-labor abundant countries:

Country	S/U	$\log(S/U)$
New Zealand	3.369	1.215
Hungary	3.086	1.127
Norway	3.010	1.102
Canada	3.008	1.101
Denmark	2.999	1.098
Australia	2.981	1.092
Finland	2.833	1.041
Sweden	2.825	1.039
Israel	2.818	1.036
Belgium	2.768	1.018

10 most unskilled-labor abundant countries:

Country Name	S/U	$\log(S/U)$
Niger	1.075	0.072
Guinea-Bissau	1.078	0.075
Benin	1.098	0.094
Mali	1.116	0.110
Rwanda	1.119	0.113
Gambia	1.119	0.113
Sudan	1.130	0.122
Mozambique	1.156	0.145
Central African Republic	1.184	0.169
Nigeria	1.217	0.196

Note: The relative abundance of skilled labor to unskilled labor (S/U) is measured as the human capital to labor ratio provided by Hall and Jones (1999).

Table 4.1: Relative Skilled-labor (*S*) and Unskilled-labor (*U*) Intensity of Manufacturing Industries: for 4-digit U.S. SIC Industries, Year 1992

Summary Statistics:

Variables	Mean	Std. Dev.	Min.	Max.
S-intensity	0.296	0.124	0.078	0.827
U-intensity	0.704	0.124	0.173	0.922

Number of manufacturing industries: 394

10 Most Skilled-labor Intensive Industries

SIC	Industry Description	*S*-intensity	*U*-intensity
2721	Periodicals	0.827	0.173
2731	Book Publishing	0.766	0.234
3571	Electronic Computers	0.718	0.282
3761	Guided Missiles & Space Vehicles	0.685	0.315
2711	Newspapers	0.676	0.324
2741	Miscellaneous Publishing	0.638	0.362
2835	Diagnostic Substances	0.633	0.367
3572	Computer Storage Devices	0.627	0.373
3826	Analytical Instruments	0.617	0.383
2086	Bottled and Canned Soft Drinks	0.604	0.396

10 Most Unskilled-labor Intensive Industries

SIC	Industry Description	*S*-intensity	*U*-intensity
2322	Men's & Boys' Underwear & Nightwear	0.078	0.922
2281	Yarn Spinning Mills	0.089	0.911
2284	Thread Mills	0.097	0.903
2211	Weaving Mills, Cotton	0.102	0.898
2436	Softwood Veneer and Plywood	0.105	0.895
2015	Poultry and Egg Processing	0.108	0.892
3263	Fine Earthenware Food Utensils	0.111	0.889
2325	Men's & Boys' Trousers & Slacks	0.116	0.884
2321	Shirts, Men's and Boys'	0.120	0.880
3144	Women's Footwear, Except Athletic	0.120	0.880

Notes:
1. The data for factor intensity is from the 1992 U.S. Census of Manufactures.
2. Industries are classified according to the 4-digit U.S. Standard Industrial Classification (SIC; 1987 version).
3. Skilled-labor (*S*) intensity is defined as the share of non-production workers in the total employment; and unskilled-worker (*U*) intensity is defined as the share of production workers. The sum of *S*-intensity and *U*-intensity is thus one for each industry.

Table 4.2: Relative Skilled-labor (*S*) and Unskilled-labor (*U*) Intensity of Manufacturing Industries: for 6-digit NAICS Industries, Year 1997

Summary Statistics:

Variables	Mean	Std. Dev.	Min.	Max.
S-intensity	0.285	0.111	0.095	0.654
U-intensity	0.715	0.111	0.346	0.905

Number of manufacturing industries: 383

10 Most Skilled-labor Intensive Industries

NAICS	Industry Description	*S*-intensity	*U*-intensity
334511	Search, detection, navigation, & guidance instrument	0.654	0.346
336414	Guided missile & space vehicle	0.640	0.360
334111	Electronic computer	0.639	0.361
334516	Analytical laboratory instrument	0.629	0.371
334210	Telephone apparatus	0.596	0.404
332995	Other ordnance & accessories	0.594	0.406
334517	Irradiation apparatus	0.582	0.418
312112	Bottled water	0.579	0.421
312111	Soft drink	0.568	0.432
334119	Other computer peripheral equipment	0.562	0.438

10 Most Unskilled-labor Intensive Industries

NAICS	Industry Description	*S*-intensity	*U*-intensity
321212	Softwood veneer & plywood	0.095	0.905
313111	Yarn spinning mills	0.098	0.902
315221	Men's & boys' cut & sew underwear & nightwear	0.098	0.902
315224	Men's & boys' cut & sew trouser, slack, & jean	0.104	0.896
313113	Thread mills	0.107	0.893
311615	Poultry processing	0.109	0.891
327213	Glass container	0.118	0.882
335222	Household refrigerator & home freezer	0.125	0.875
335224	Household laundry equipment	0.127	0.873
321211	Hardwood veneer & plywood	0.128	0.872

Notes:
1. The data for factor intensity is from the 1997 U.S. Census of Manufactures.
2. Industries are classified according to the 6-digit 1997 North American Industry Classification System (NAICS).
3. Skilled-labor (*S*) intensity is defined as the share of non-production workers in the total employment; and unskilled-worker (*U*) intensity is defined as the share of production workers. The sum of *S*-intensity and *U*-intensity is thus one for each industry.

Table 4.3: Relative Skilled-labor (*S*) and Unskilled-labor (*U*) Intensity of Manufacturing Industries: for 6-digit NAICS Industries, Year 2002

Summary Statistics:

Variables	Mean	Std. Dev.	Min.	Max.
S-intensity	0.301	0.120	0.087	0.711
U-intensity	0.699	0.120	0.289	0.913

Number of manufacturing industries: 384

10 Most Skilled-labor Intensive Industries

NAICS	Industry Description	*S*-intensity	*U*-intensity
334210	Telephone apparatus	0.711	0.289
334111	Electronic computer	0.704	0.296
334119	Other computer peripheral equipment	0.670	0.330
334511	Search, detection, navigation, & guidance instrument	0.666	0.334
334517	Irradiation apparatus	0.664	0.336
334516	Analytical laboratory instrument	0.662	0.338
334515	Electricity measuring & testing instrument	0.660	0.340
333295	Semiconductor machinery	0.639	0.361
336414	Guided missile & space vehicle	0.628	0.372
336415	Guided missile & space vehicle propulsion unit & parts	0.619	0.381

10 Most Unskilled-labor Intensive Industries

NAICS	Industry Description	*S*-intensity	*U*-intensity
321212	Softwood veneer & plywood	0.087	0.913
313111	Yarn spinning mills	0.101	0.899
311615	Poultry processing	0.108	0.892
335222	Household refrigerator & home freezer	0.126	0.874
336111	Automobile	0.130	0.870
327213	Glass container	0.131	0.869
313210	Broadwoven fabric mills	0.131	0.869
321113	Sawmills	0.135	0.865
311611	Animal (except poultry) slaughtering	0.135	0.865
311411	Frozen fruit, juice, & vegetable	0.139	0.861

Notes:
1. The data for factor intensity is from the 2002 U.S. Census of Manufactures.
2. Industries are classified according to the 6-digit 2002 North American Industry Classification System (NAICS).
3. Skilled-labor (*S*) intensity is defined as the share of non-production workers in the total employment; and unskilled-worker (*U*) intensity is defined as the share of production workers. The sum of *S*-intensity and *U*-intensity is thus one for each industry.

Table 5: List of Countries in Aggregate North and South

North (51 countries)		South (64 Countries)	
Argentina[#, ##]	Norway	Algeria	Mali
Australia	Panama[#, ##]	Angola	Mauritania
Austria[#, ##]	Peru[#, ##]	Bangladesh	Mauritius
Barbados	Philippines[#, ##]	Benin	Mexico
Belgium	Poland	Bolivia	Mozambique
Canada	South Korea	Brazil	Nicaragua
Chile[#, ##]	South Africa[#, ##]	Burkina Faso	Niger
China[#, ##]	Spain[#, ##]	Burundi	Nigeria
Costa Rica[#, ##]	Sri Lanka[#, ##]	Cote d'Ivoire	Oman
Cyprus	Sweden	Cameroon	Pakistan
Czechoslovakia[*]	Switzerland	Central African Republic	Papua New Guinea
Denmark	Taiwan[##]	Chad	Paraguay
Ecuador[#, ##]	Thailand[#, ##]	Colombia	Portugal
Egypt[#, ##]	Trinidad and Tobago[#, ##]	Congo	Reunion
Fiji[##]	United Kingdom	Dominican Republic	Rwanda
Finland	Uruguay[#, ##]	El Salvador	Saudi Arabia
France[#, ##]	U.S.S.R.[*]	Gabon	Senegal
Germany	Venezuela[#, ##]	Gambia	Seychelles
Greece[##]	Yugoslavia[*]	Ghana	Sierra Leone
Guyana[#, ##]		Guatemala	Singapore
Hong Kong		Guinea	Somalia
Hungary		Guinea-Bissau	Sudan
Iceland		Haiti	Suriname
Ireland		Honduras	Syria
Israel		India	Togo
Italy[#, ##]		Indonesia	Tunisia
Japan		Iran	Turkey
Malaysia[#, ##]		Jamaica	Uganda
Malta[##]		Jordan	Tanzania
Morocco[#, ##]		Kenya	Zaire
Netherlands		Madagascar	Zambia
New Zealand		Malawi	Zimbabwe

Notes:

1. The aggregate North consists of countries whose skilled-to-unskilled labor ratio (S/U) is above the average of the 115 countries (1.879); and the aggregate South consists of countries with S/U below the average.
2. Countries marked with # are grouped into the South if the 75 percentile value of S/U is applied to the North-South cutoff (22 countries in the North and 93 in the South); and countries with ## are grouped into the South if the 0.7 of the U.S. relative factor endowment (S/U) is applied to the cutoff (26 in the North and 89 in the South).
3. Countries marked with * are not included in the data for Years 1995 and 2000.

Table 6: Skilled-to-Unskilled Labor Ratios (*S*/*U*) of North and South

	S/*U* (average within group)	log(*S*/*U*) (average within group)
North	2.40	0.862
South	1.47	0.371

Notes:
1. Human capital to labor ratio in Hall and Jones (1999) is used as the measure of the relative factor abundance, or the ratio of skilled- to unskilled-labor (*S*/*U*), for each country.
2. The North comprises 51 countries that have the highest *S*/*U*, and the South comprises 64 countries with the lowest *S*/*U*. See Table 5 for the list of the countries in each group.

Table 7: Regressions for Aggregate North and South

Dependent Variable = Log of the aggregate number of varieties as the share in the total number of varieties imported by the U.S. ($\log(n\_share_{i,A})$)

Year 1990:

	North	South
Industry skill intensity ($skill_i$)	0.260*** (0.049)	-1.21*** (0.201)
Constant	-0.275*** (0.016)	-1.56*** (0.061)
Observations	394	385
R^2	0.08	0.12

Year 1995:

	North	South
Industry skill intensity ($skill_i$)	0.260*** (0.048)	-1.25*** (0.186)
Constant	-0.326*** (0.015)	-1.48*** (0.057)
Observations	383	378
R^2	0.08	0.12

Year 2000:

	North	South
Industry skill intensity ($skill_i$)	0.131* (0.070)	-0.866*** (0.143)
Constant	-0.325*** (0.020)	-1.52*** (0.046)
Observations	384	379
R^2	0.02	0.10

Notes:
1. Regressions estimate Equation (4.1) in the text for each year.
2. Robust standard errors are in parentheses.
3. ***, **, and * indicate that the coefficient estimate is significant at the 1% level, 5% level, and 10% level, respectively.

Table 8: Pooled Regressions for Individual Exporters

Dependent Variable = Log of the number of exported varieties in each industry as the share in the total number of varieties imported by the U.S. (log(n_share_{ic}))

Year 1990:

$skill_i$	-1.80***
	(0.433)
$skill_i$ * log(S/U)$_c$	2.42***
	(0.522)
Observations	17,050
R^2	0.15

Year 1995:

$skill_i$	-2.38***
	(0.456)
$skill_i$ * log(S/U)$_c$	2.93***
	(0.537)
Observations	17,469
R^2	0.17

Year 2000:

$skill_i$	-1.98***
	(0.363)
$skill_i$ * log(S/U)$_c$	2.35***
	(0.450)
Observations	19,037
R^2	0.18

Notes:
1. Regressions estimate Equation (4.4) in the text for each year. Country-specific dummies are included.
2. $skill_i$ is skilled-labor intensity of each industry, and $(S/U)_c$ is skilled-to-unskilled labor endowment ratio in each country.
3. Standard errors in parentheses are clustered by country.
4. ***, **, and * indicate that the coefficient estimate is significant at the 1% level, 5% level, and 10% level, respectively.

Table 9: Pooled Regressions using Alternative Measure of Export Varieties

Dependent Variable = Measure of "Relative Product Variety" in exports (RV_{ic}), in natural scale or logarithm

Year 1990:

	RV_{ic}	$\log(RV_{ic})$
$skill_i$	-0.030^{***}	-1.63^{***}
	(0.007)	(0.501)
$skill_i * \log(S/U)_c$	0.044^{***}	2.37^{***}
	(0.011)	(0.629)
Observations	17,050	17,048
R^2	0.06	0.08

Year 1995:

	RV_{ic}	$\log(RV_{ic})$
$skill_i$	-0.027^{***}	-2.13^{***}
	(0.005)	(0.572)
$skill_i * \log(S/U)_c$	0.037^{***}	2.90^{***}
	(0.007)	(0.671)
Observations	17,469	17,469
R^2	0.07	0.10

Year 2000:

	RV_{ic}	$\log(RV_{ic})$
$skill_i$	-0.015^{***}	-1.26^{***}
	(0.004)	(0.454)
$skill_i * \log(S/U)_c$	0.019^{***}	1.89^{***}
	(0.007)	(0.573)
Observations	19,037	19,036
R^2	0.07	0.10

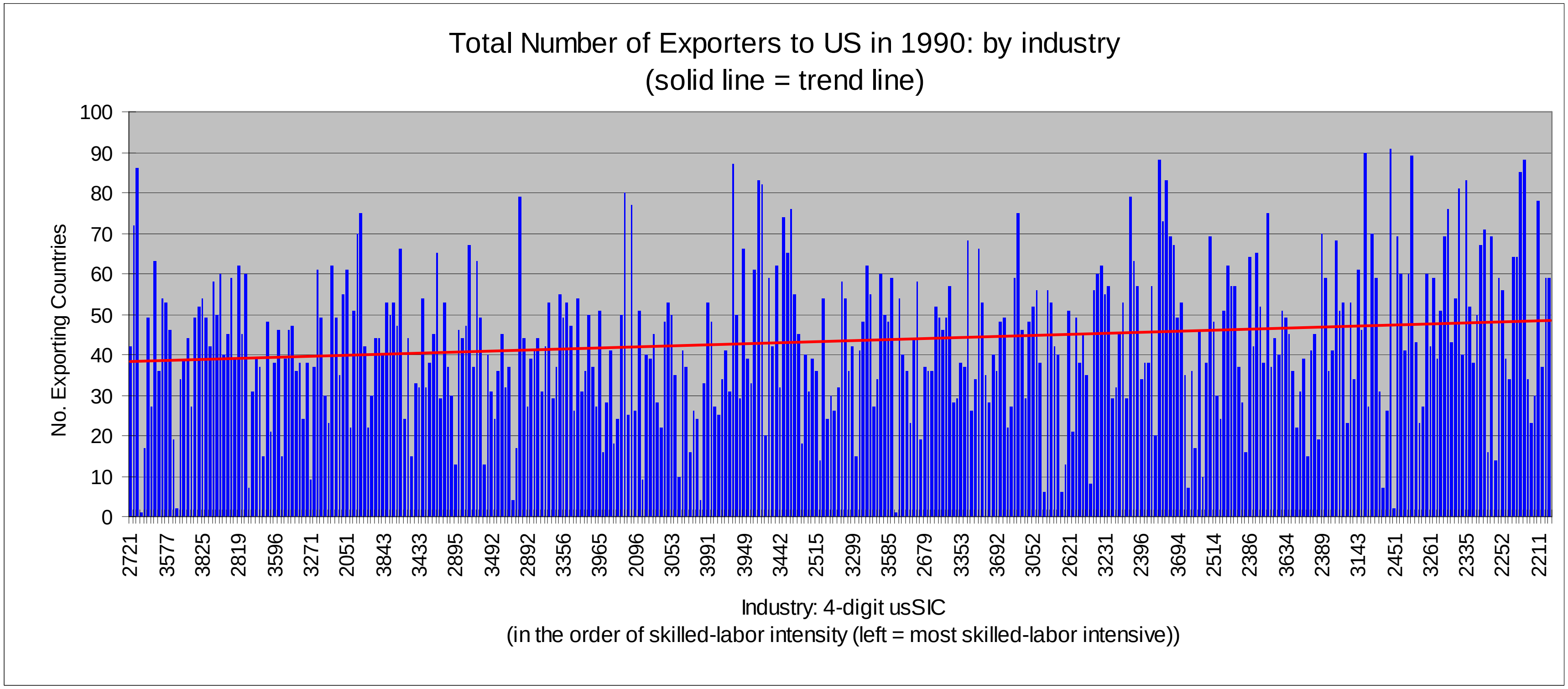
Notes:

1. The measure of relative product variety is defined as follows:

$$RV_{ic} \equiv \frac{\sum_{\omega \in \Omega_i^c} p_\omega^* x_\omega^*}{\sum_{\omega \in \Omega_i^*} p_\omega^* x_\omega^*}$$

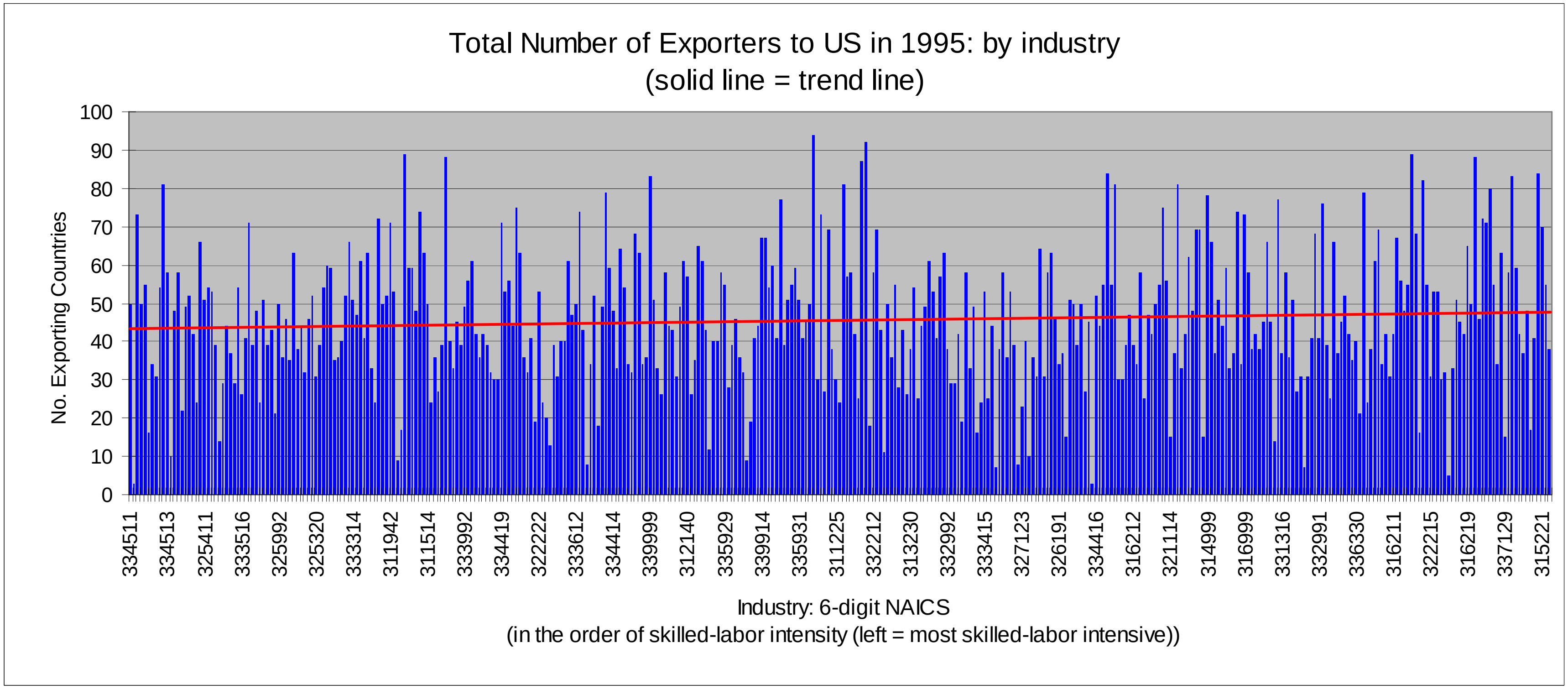
2. Regressions estimate Equations (4.5) and (4.6) in the text for each year. Country-specific dummies are included.
3. $skill_i$ is skilled-labor intensity of each industry, and $(S/U)_c$ is skilled-to-unskilled labor endowment ratio in each country.
4. Standard errors in parentheses are clustered by country.
5. ***, **, and * indicate that the coefficient estimate is significant at the 1% level, 5% level, and 10% level, respectively.

Figure 1.1: Number of Exporters to the U.S. in Each Manufacturing Industry; Year 1990



Notes:
1. Industries are classified according to the 4-digit 1987 U.S. Standard Industrial Classification (SIC).
2. 394 manufacturing industries are listed in the order of skilled-labor intensity; the left is the most skilled-labor intensive, and the right is the least.
3. Skilled-labor intensity is defined as the share of non-production workers in the total number of employees.

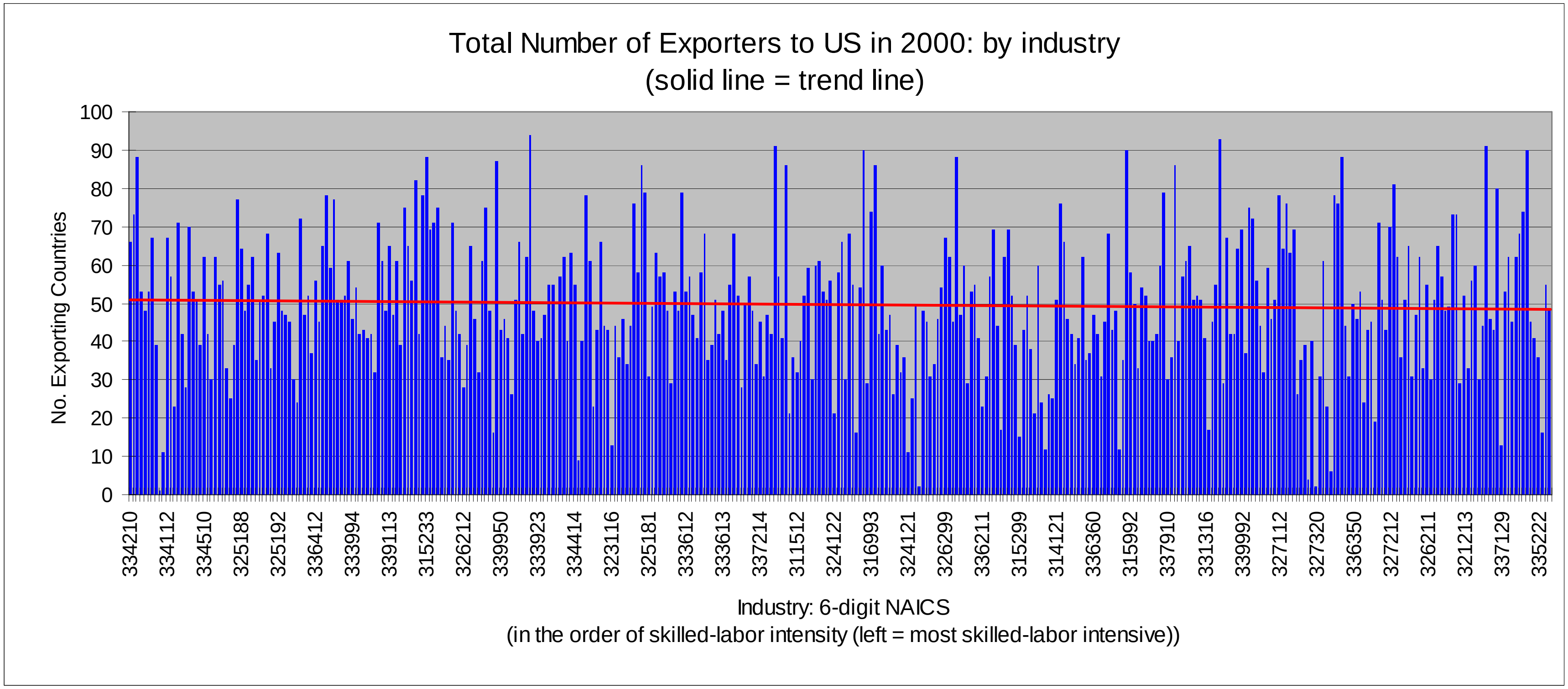
Figure 1.2: Number of Exporters to the U.S. in Each Manufacturing Industry; Year 1995



Notes:

1. Industries are classified according to the 6-digit 1997 North American Industry Classification System (NAICS).
2. 383 manufacturing industries are listed in the order of skilled-labor intensity; the left is the most skilled-labor intensive, and the right is the least.
3. Skilled-labor intensity is defined as the share of non-production workers in the total number of employees.

Figure 1.3: Number of Exporters to the U.S. in Each Manufacturing Industry; Year 2000



Notes:
1. Industries are classified according to the 6-digit 2002 North American Industry Classification System (NAICS).
2. 384 manufacturing industries are listed in the order of skilled-labor intensity; the left is the most skilled-labor intensive, and the right is the least.
3. Skilled-labor intensity is defined as the share of non-production workers in the total number of employees.

Figure 2.1: Number of Exporters vs Industry Skilled-labor Intensity in the U.S. Manufacturing Imports; Year 1990

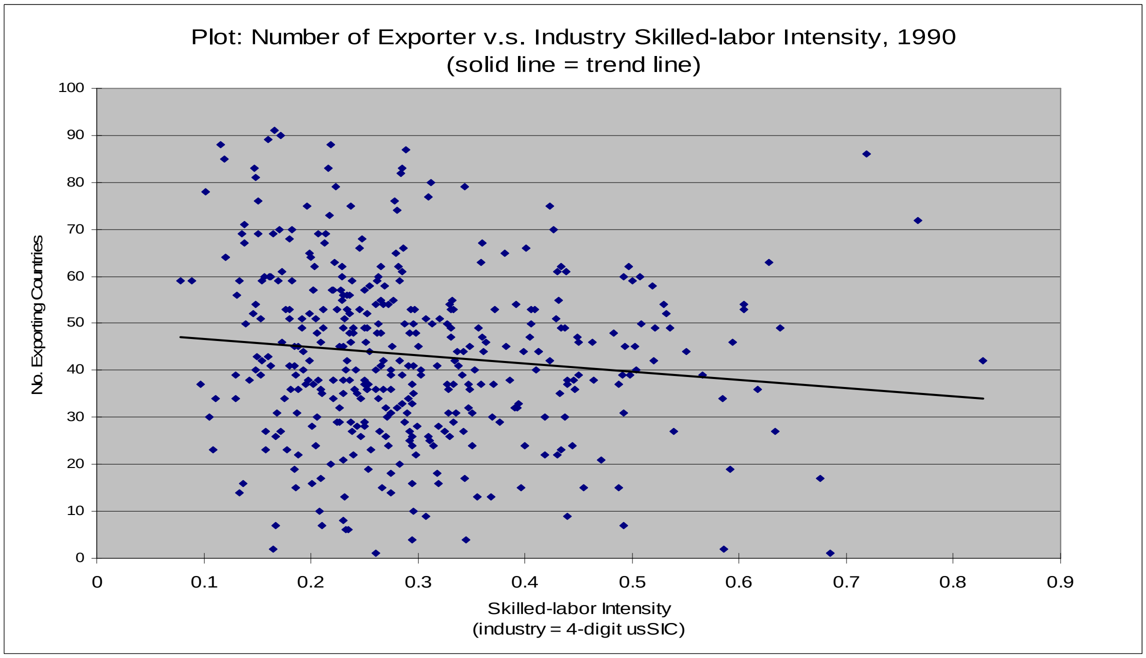


Figure 2.2: Number of Exporters vs Industry Skilled-labor Intensity in the U.S. Manufacturing Imports; Year 1995

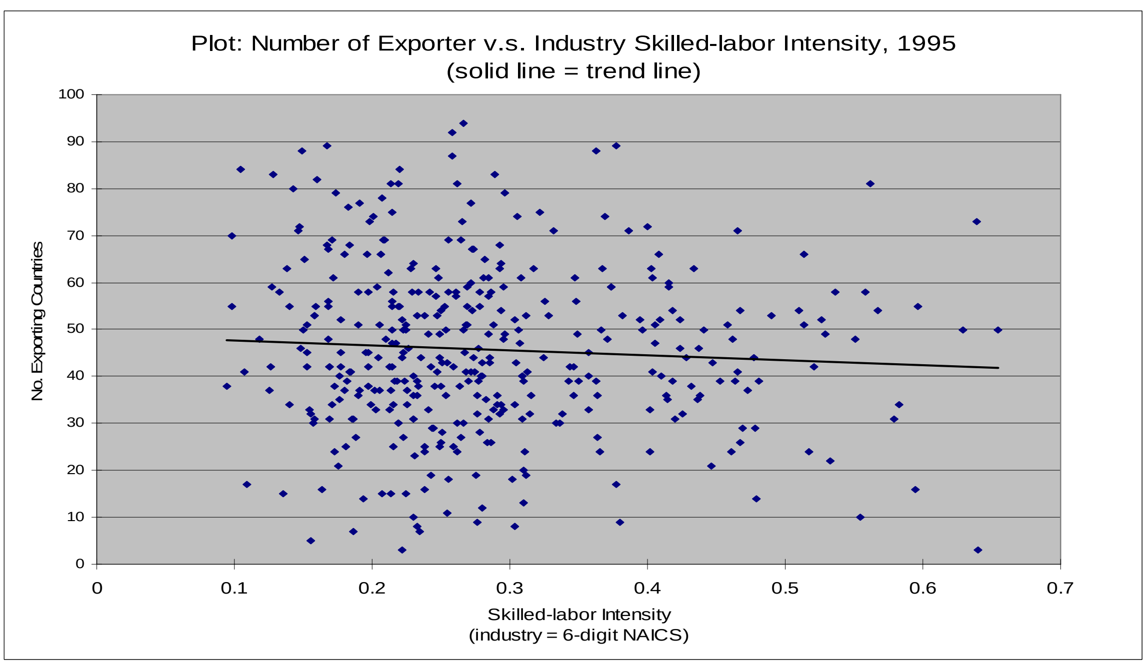
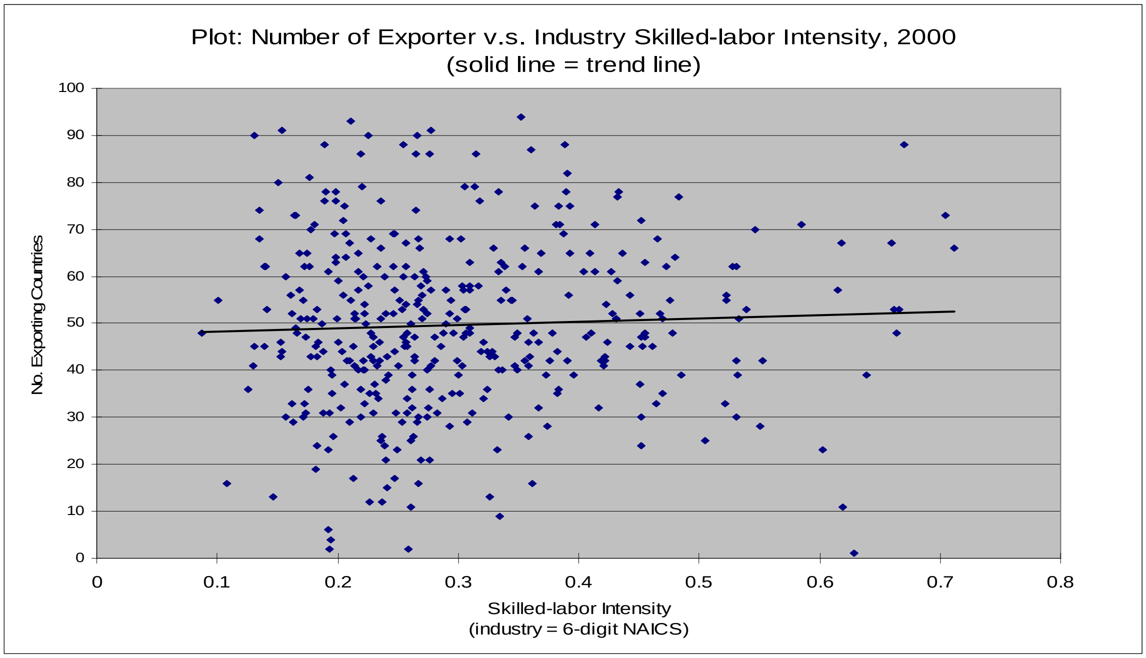


Figure 2.3: Number of Exporters vs Industry Skilled-labor Intensity in the U.S. Manufacturing Imports; Year 2000



Notes on Figures 2.1 through 2.3:

1. Manufacturing industries are classified according to the 4-digit 1987 U.S. SIC for the year 1990, and according to the 6-digit 1997 NAICS for the years 1995 and 2000.

2. The number of exporters is the number of countries from which the United States imports in each manufacturing industry.

3. Skilled-labor intensity is defined as the share of non-production workers in the total number of employees in each industry.

Figure 3.1: Number of Varieties vs Industry Skilled-labor Intensity in the U.S. Manufacturing Imports; Year 1990

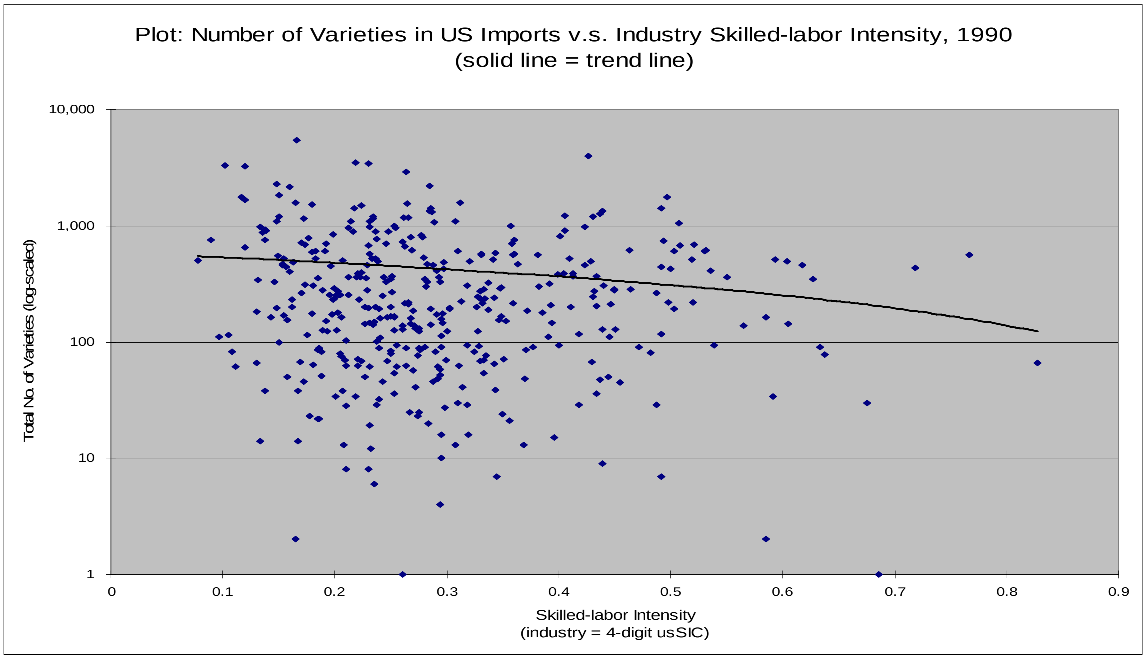


Figure 3.2: Number of Varieties vs Industry Skilled-labor Intensity in the U.S. Manufacturing Imports; Year 1995

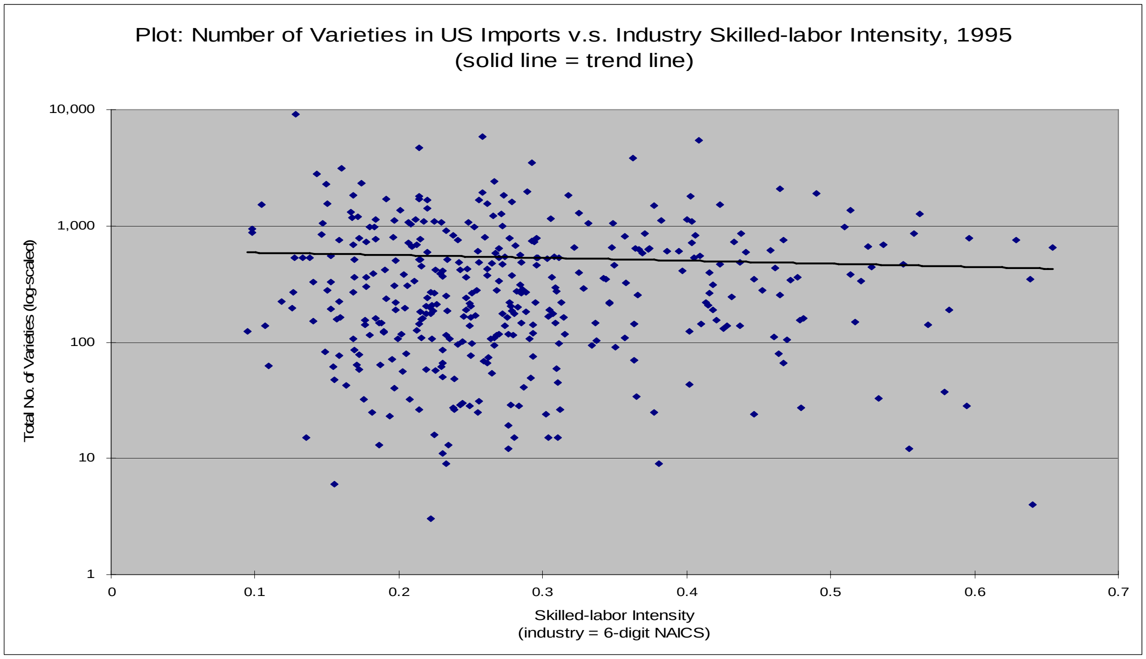
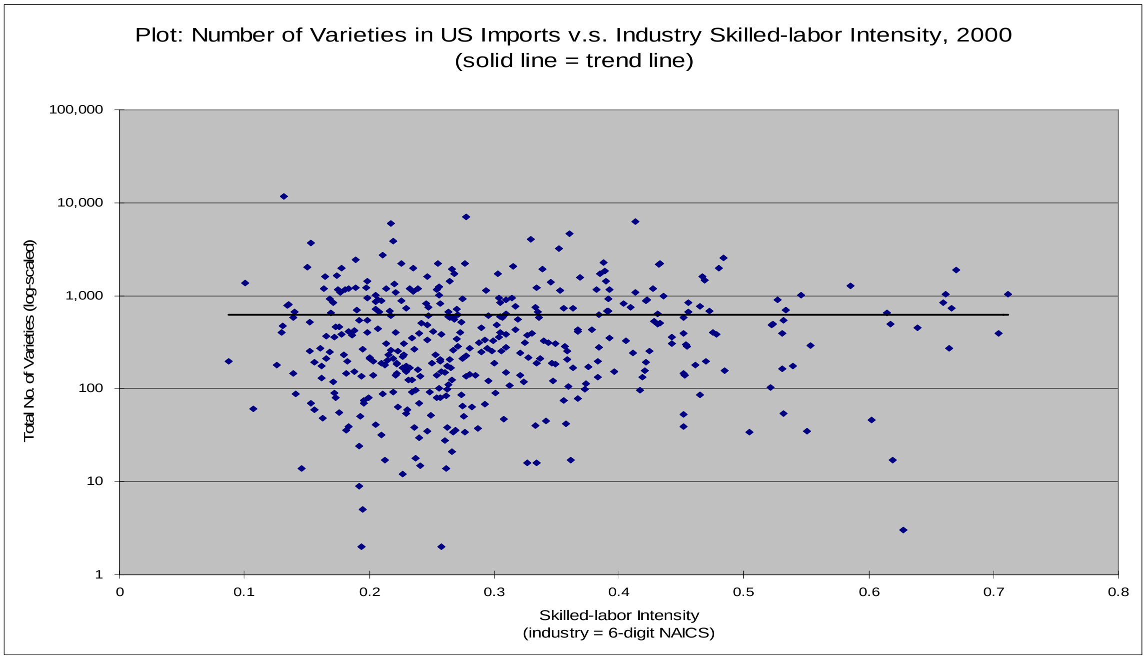


Figure 3.3: Number of Varieties vs Industry Skilled-labor Intensity in the U.S. Manufacturing Imports; Year 2000



Notes on Figures 3.1 through 3.3:

1. Manufacturing industries are classified according to the 4-digit 1987 U.S. SIC for the year 1990, and according to the 6-digit 1997 NAICS for the years 1995 and 2000.
2. The number of varieties in each industry is defined as the number of 10-digit HS goods that the U.S. imports *from each country* in each 4-digit SIC industry (i.e., the same 10-digit HS products imported from different countries are counted as different varieties).
3. Skilled-labor intensity is defined as the share of non-production workers in the total number of employees in each industry.

Figure 4.1: Individual Exporter Country Regression for 1990: Slope Coefficient vs Skill Abundance of the Country

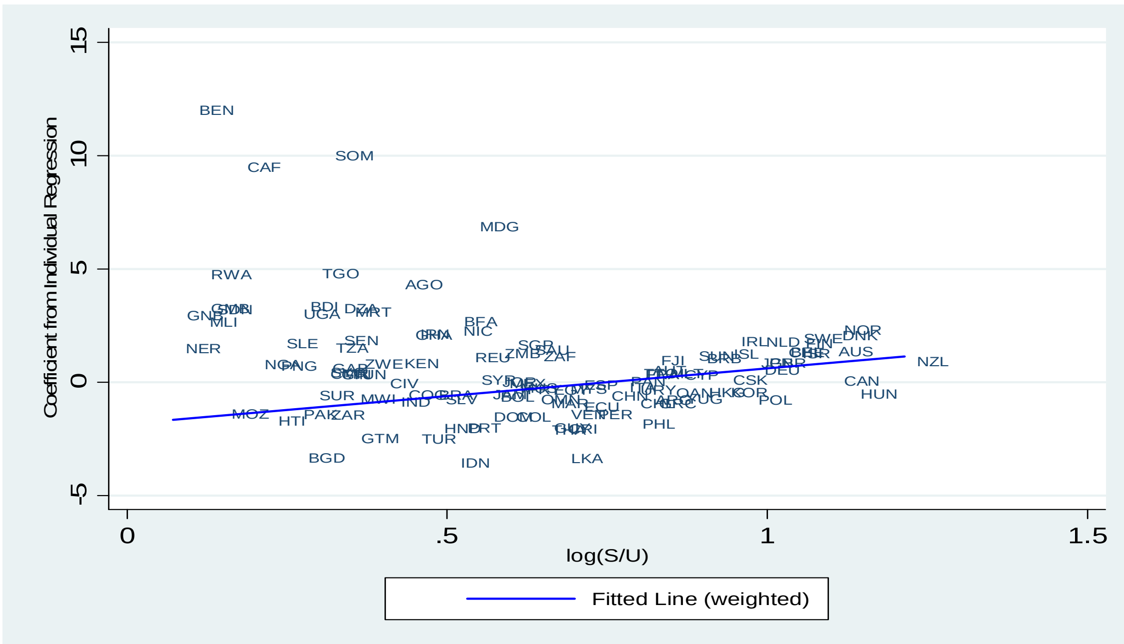


Figure 4.2: Individual Exporter Country Regression for 1995: Slope Coefficient vs Skill Abundance of the Country

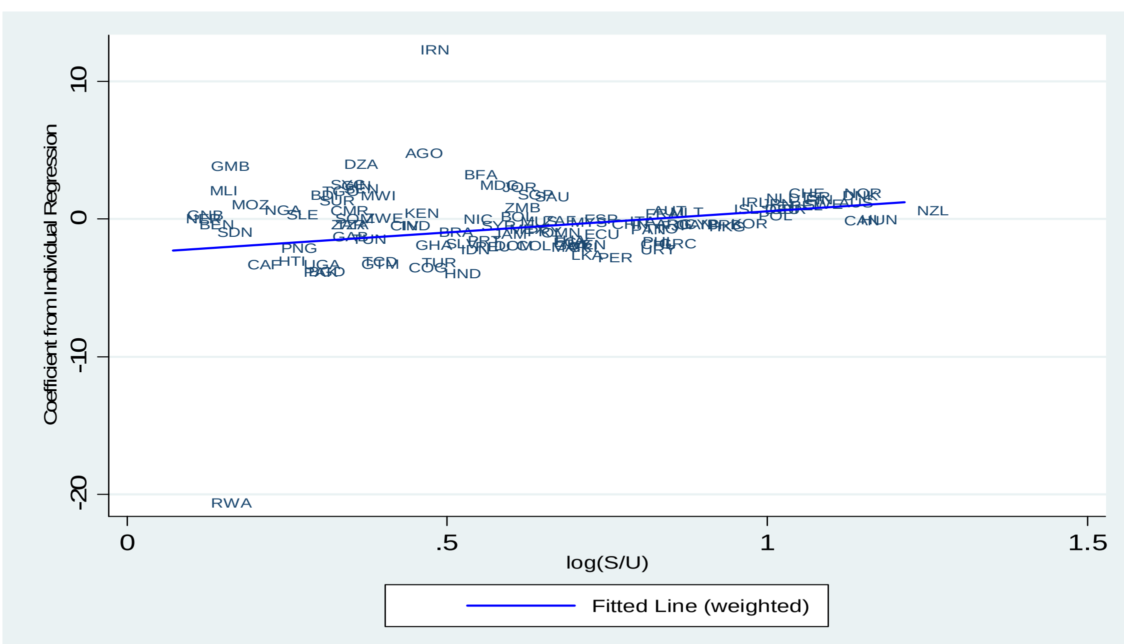
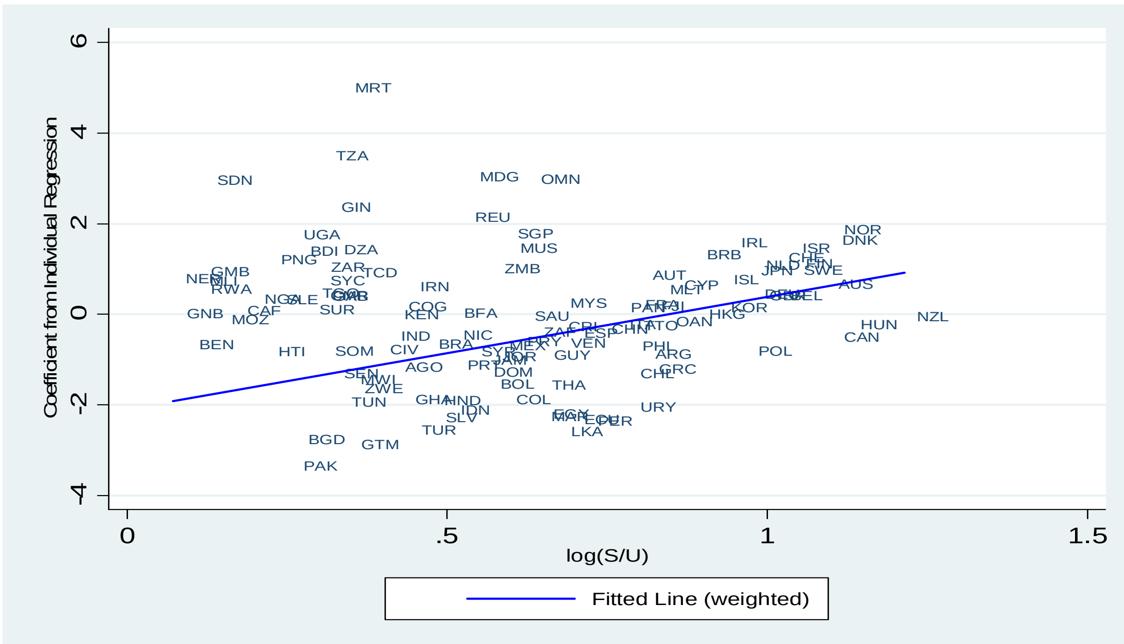


Figure 4.3: Individual Exporter Country Regression for 2000: Slope Coefficient vs Skill Abundance of the Country



Notes on Figures 4.1 through 4.3:

1. The individual regressions estimate the equation $\log(n\_share_{i,c}) = \gamma_c + \Pi_c skill_i + \varepsilon_{i,c}$, where i indexes 4-digit SIC industries (for the year 1990) or 6-digit NAICS industries (for the years 1995 and 2000), and c indexes exporter countries. The regression is performed for each country to estimate the country-specific slope coefficient $\hat{\Pi}_c$ for each year.

2. The figures plot $\hat{\Pi}_c$ for each country (marked by the ISO country code) against the skilled-labor to unskilled-labor ratio of the country ($(S/U)_c$) in logarithm.

3. The fitted line in each figure is based on the weighted regression of $\hat{\Pi}_c$ on $\log(S/U)_c$ with the observations weighted by the number of 4-digit SIC industries for each country in the sample. (That is, the weight is the number of observation used for each individual country regression.)